CONCRETE AND CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

APRIL, 1955. **Vol. L, No. 4**

FIFTIETH YEAR OF PUBLICATION

PRICE 1s. 6d. ANNUAL SUBSCRIPTION 18s., POST FREE. $3·90 in Canada and U.S.A.

LEADING CONTENTS

No. 569. ISSUED MONTHLY *Registered for Canadian Magazine Post*

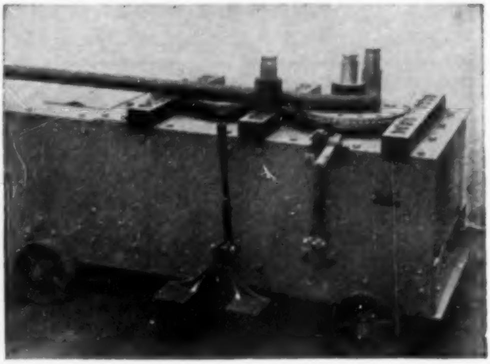
A

POWER BAR BENDERS
FOR ALL SIZES OF
REINFORCING BARS

STANDARD PRODUCTION MODELS

The ARD. 50 MODEL—as illustrated on right—has a capacity for cold bending Mild Steel Bars up to 2" dia. and incorporates a second Bending Head to give high-rate bending for small diameter bars.

The RAS. 40 MODEL shown below is a single disc machine of exceptional performance. With a capacity for 1¼" dia. bars, it bends at highest practical rate—e.g. a full hook takes only 3 seconds bending time.



Ensure accuracy, economy & simplicity of operation

INTERESTING FEATURES

Either of the Models illustrated can be supplied motorised or engine driven.

Standard Accessories supplied include all necessary Formers and Bending Pins, a special Backrest for simultaneous bending of a number of small diameter bars, and Accessories for forming right-angle loops in one operation.

Special Safety Device incorporated to prevent damage to mechanism if overloaded.

The desired Bending Angle may be set mathematically, and this is of great assistance in Repetition Bending.

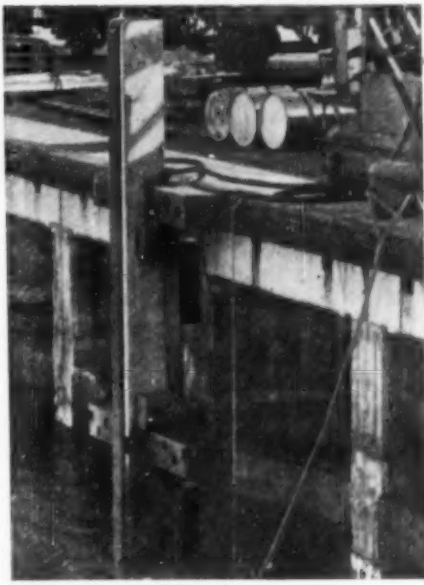
CEMENT & STEEL LTD.

SECOND AVENUE CHATHAM KENT

Telephone: Chatham 45580 *Telegrams and Cables: Cembelgi, Chatham*

S.S. "Kronpins Frederik" coming alongside the rebuilt Parkeston Quay.

Close up of timber fender backed by three Goodyear Rubber Fenders, each 10 ins. by 8 ins. by 2 ft. 6 ins.



DEEP DEFENCE

Parkeston Quay's new fendering

MOST important feature of the new fendering system at the rebuilt Parkeston Quay, Harwich, is the disposition of highly efficient shock absorbers—Goodyear Rubber Fender sections—behind hanging greenheart fenders.

These rectangular rubber sections ensure that all types of vessels using the quay are effectively protected *at all states of the tide and in any weather*.

Each Goodyear section can compress to a third of its original thickness and withstand continual heavy impacts without damage or loss of its remarkable resilience.

To give the necessary comprehensive protection, it was decided by the Chief Civil Engineer, Eastern Region, British Railways, to fit three short lengths of Goodyear Dock Fender behind each of the timber fenders along 900 feet of the quay. One length is installed just below the cill, the second below H.W.O.S.T. level, and the third below L.W.O.S.T. level.

This deep grouping of Goodyear Dock Fenders behind a hanging greenheart facing gives full protection at very low maintenance and replacement expense for all the demanding local characteristics: (a) Tidal range of 12ft; (b) Vessels up to 5,000 tons, some belted and others requiring catamarans; (c) Vessels being handled up to 4 or 5 at a time, on quick-turn-round schedules.

ADVISORY SERVICE

There are many different ways of installing Goodyear Rubber Fenders, and many different applications: Goodyear engineers will be glad to advise on the simplest and most effective application for harbour installation, vessels or industrial equipment.

MOST VERSATILE

Whatever the tide, climate and traffic conditions and whether used by itself or with other materials, Goodyear Rubber Fendering is the most economical and versatile protection for docks, quays, harbours, dolphins and piers—and the vessels using them.

Proof of this is in the ever-growing number of port and harbour authorities throughout the world who are choosing fendering by Goodyear.

It has an exceptional life-span, does not deteriorate through contact with sludge oil, through heat, or through attack by termites and other borers.

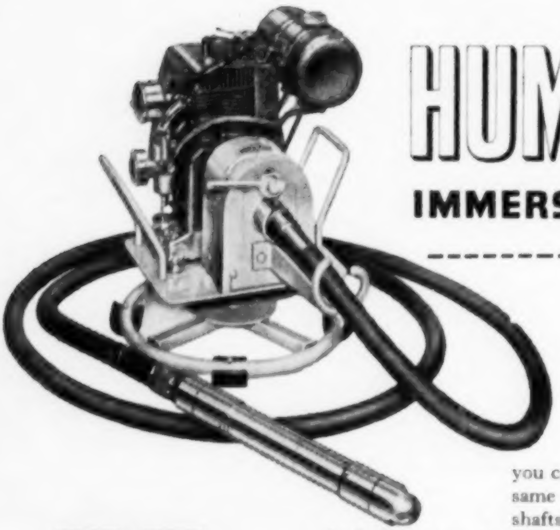
A typical Goodyear installation has seen continual heavy service for over 20 years and is still in excellent condition.

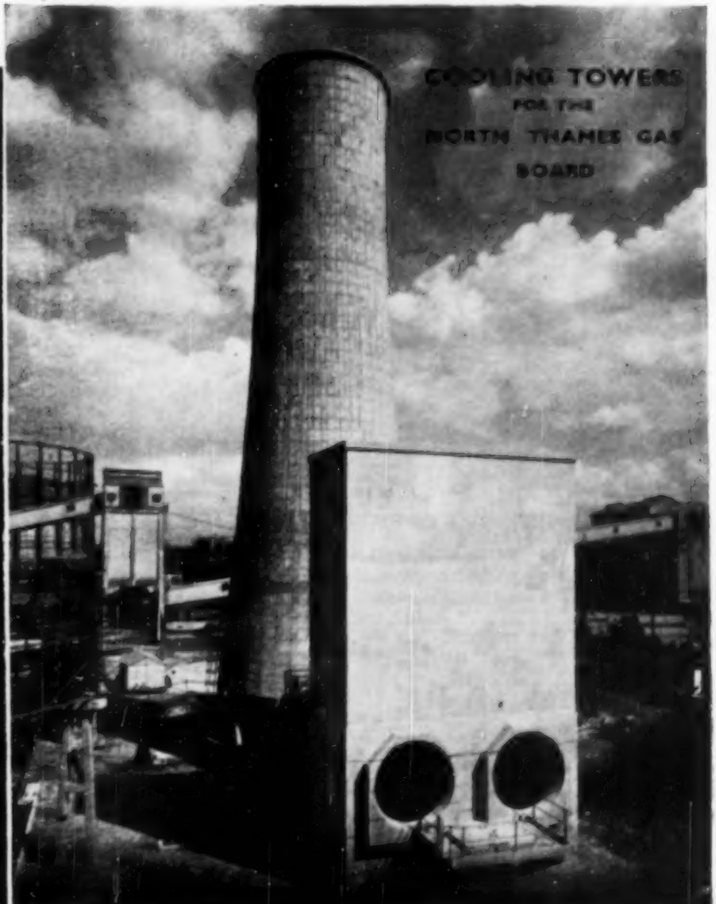
GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

Fendering · V-Belts · Hose · Transmission & Conveyor Belts

THE GOODYEAR TYRE & RUBBER CO. (GT. BRITAIN) LTD., INDUSTRIAL RUBBER PRODUCTS DEPT., WOLVERHAMPTON. EXPORT ENQUIRIES: 17 STRATTON STREET, LONDON, W.1



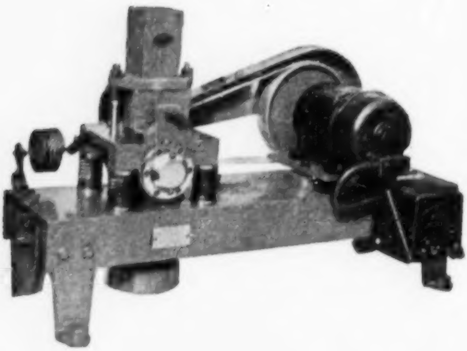


CONSULTING ENGINEERS: L. G. MOUCHEL & PARTNERS, LTD.

PETER LIND & CO LTD

ROMNEY HOUSE, TUFTON STREET, LONDON, S.W.1

TELEPHONE ABBEY 7361



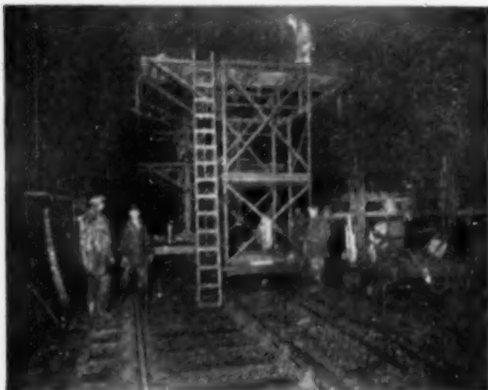
CEMENTATION

stops water penetration

of Tunnels, Basements, Shafts, Sewers and similar structures

Over a mile of the Severn Railway Tunnel has been successfully treated by Cementation to stop water penetration. The mortar jointing of the brickwork had disintegrated over large areas and the continuous inflow through the open joints had formed cavities directly behind the lining. There was a possibility of serious ground movement.

Remedial work, which included the filling of the cavities, was completed without interrupting the flow of traffic.



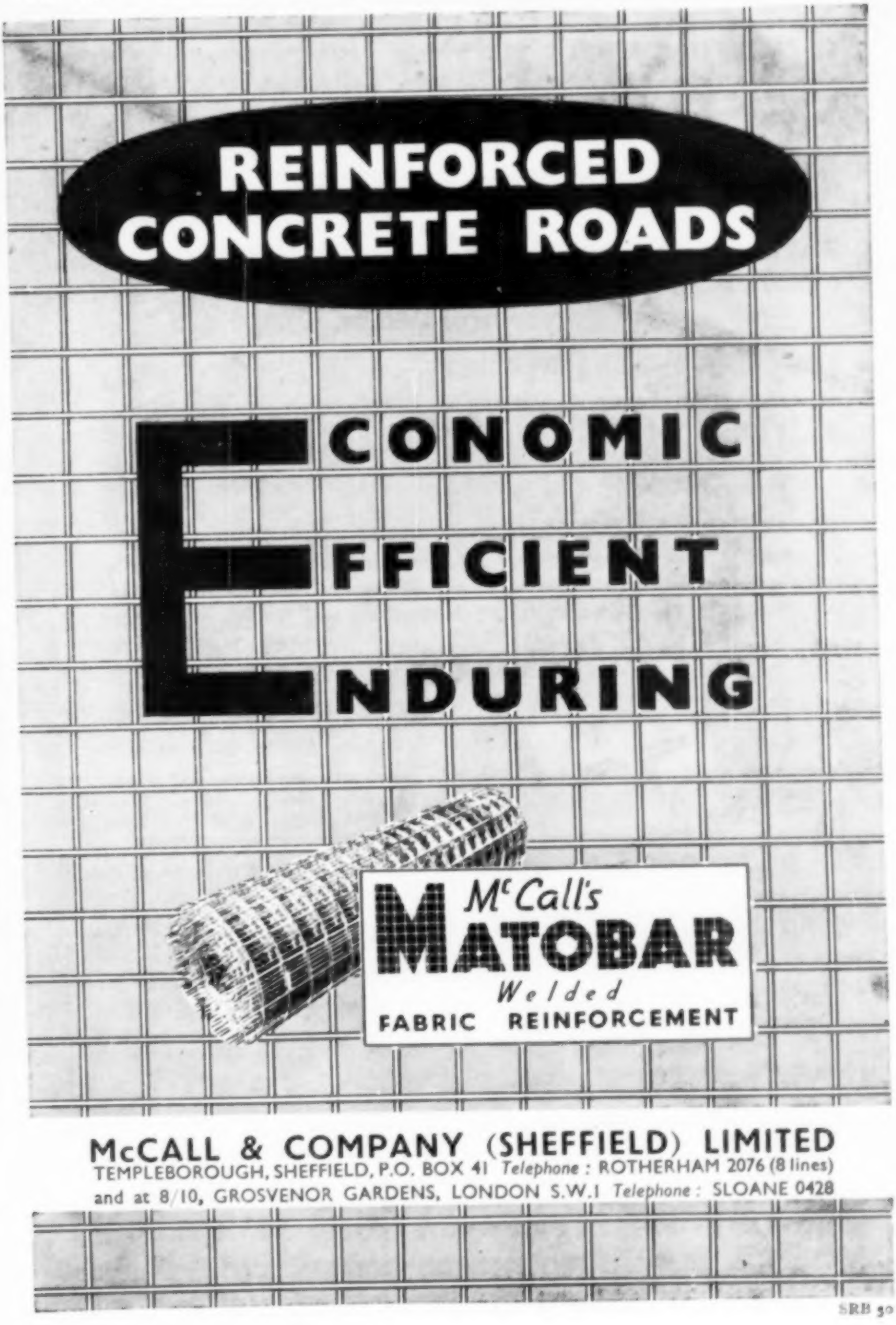
Severn Tunnel

The Cementation Co., Ltd., has the experience, the facilities, and the resources to carry out this type of work in any part of the world.

Severn Boring

The CEMENTATION COMPANY LIMITED

BENTLEY WORKS, DONCASTER. Telephone: Doncaster 54177–8–9


REINFORCED
CONCRETE ROADS
ECONOMIC
EFFICIENT
ENDURING
McCall's
MATOBAR
Welded
FABRIC REINFORCEMENT
McCALL & COMPANY (SHEFFIELD) LIMITED
TEMPLEBOROUGH, SHEFFIELD, P.O. BOX 41 Telephone: ROTHERHAM 2076 (8 lines)
and at 8/10, GROSVENOR GARDENS, LONDON S.W.1 Telephone: SLOANE 0428
SRB 50

Cromer Pier....

The reconstruction of this 500-ft. pier on behalf of the Cromer Urban District Council is now approaching completion. The contract has included the replacement of main steelwork, columns, concrete and timber decking, etc. Consulting Engineers are Messrs. Lewis & Duvivier, Victoria Street, London, S.W.1.

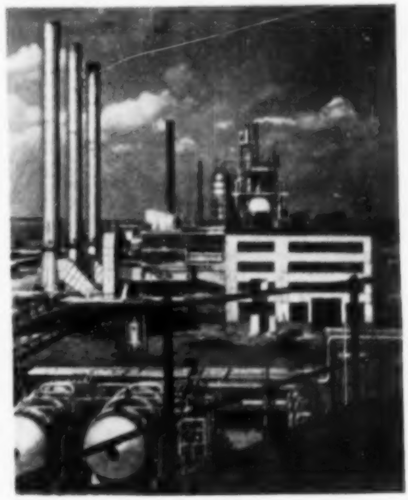
Surveyor to the Council:
J. A. Haigh, Esq., A.M.I.S.E.

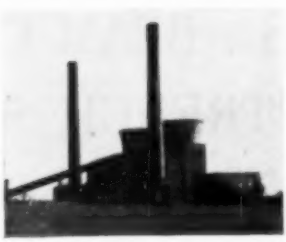
Resident Engineer:
S. M. Johnson, Esq., O.B.E., M.I.C.E.

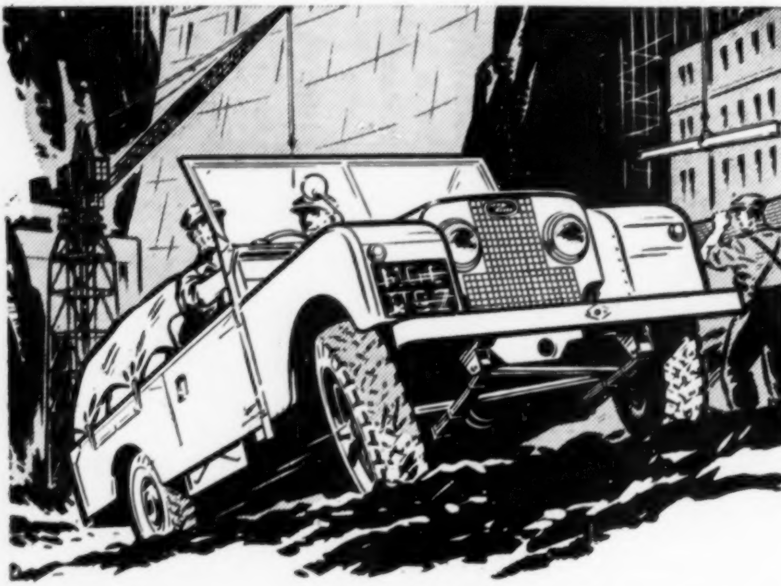
reconstruction undertaken by

CONCRETE PILING LTD

10 WESTMINSTER PALACE GARDENS ARTILLERY ROW LONDON SW1 PHONE ABBEY 1626/7
LADAS DRIVE BELFAST PHONE BELFAST 58100 WORKS RIVER ROAD BARKING PHONE RIPPLEWAY 2624







Glutton for punishment!

All over the world the name of 'Land-Rover' stands for versatility, endurance, *toughness*. That 4-wheel drive gets through . . . anywhere . . . any time. And now the powerful 52 B.H.P. engine has been still further improved. New long-life features have been incorporated . . . spread bore cylinder arrangement . . . copper-lead bearings . . . full-flow oil filter. The Land-Rover goes from strength to strength!

86" Wheelbase Standard model with detachable hood and side screens.

The Land-Rover 107" wheelbase Pick-up Truck.

The LAND-ROVER can take it!

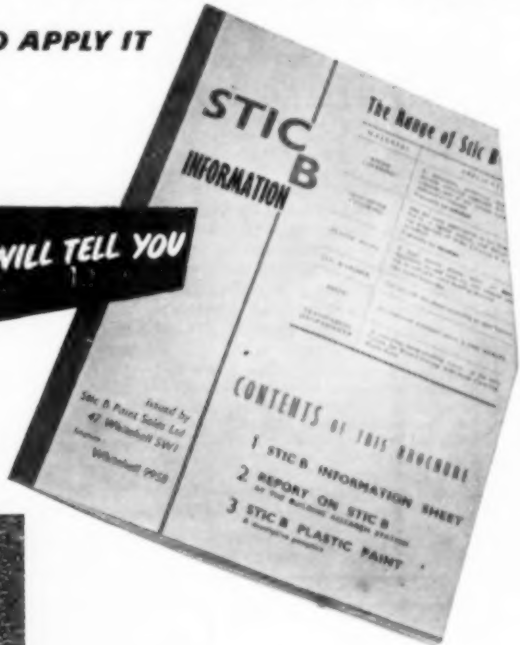
MADE BY THE ROVER CO. LTD · SOLIHULL · BIRMINGHAM also DEVONSHIRE HOUSE · LONDON

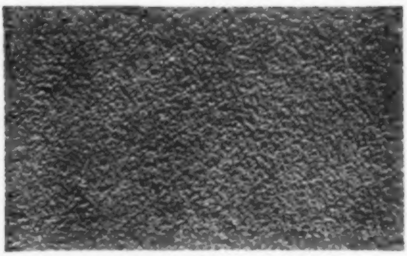
CVS-104

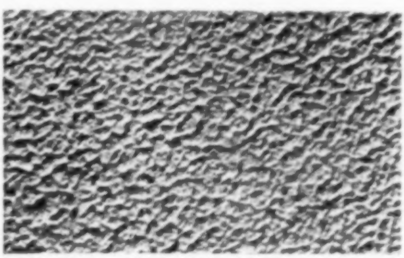
STONE COVERING PAINT

WHAT IT IS – AND HOW TO APPLY IT

THIS BOOK WILL TELL YOU




STONE COVERING—Fine Stipple


STONE COVERING—Coarse Stipple

You will find this booklet very useful. It describes the complete range of Stic B Products, their application and use by the Architect and Builder. Included also is a comprehensive report by the Building Research Station on the conditions under which our products were tested, and the impressive results that were achieved. Please write to our London office, when a copy will be sent you by return.

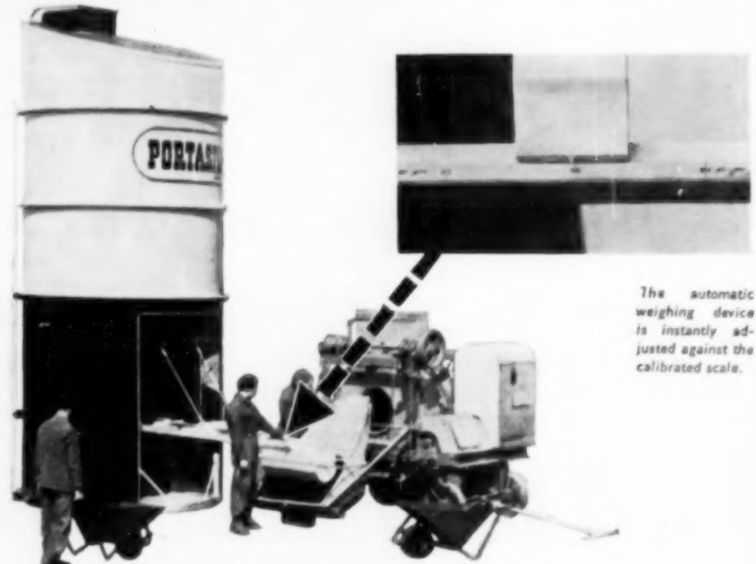
STIC B PAINT SALES LTD.

47 WHITEHALL, LONDON, S.W.1

Telephone: WHItehall 9958/9

THE PORTASILO SYSTEM REG'D

The world's most highly developed fully portable bulk cement equipment



The automatic weighing device is instantly adjusted against the calibrated scale.

The Type 201 (20 tons nominal capacity) PORTASILO.

The PORTASILO system exploits to the full the advantages of using bulk cement and utilises the pneumatic delivery system now offered by the leading cement manufacturers. Its use can effect savings of 18/- per ton of cement used. This proved and established system can be seen operating in most parts of the country. The PORTASILO is fully portable and the Type 105 Model of 10 tons nominal capacity is light enough to be man-handled. Automatic weighing of the cement is provided by the PULLWEY Mechanical Cement Man. The PORTASILO illustrated is the Type 201 of 20 tons nominal capacity. Other models of 10 tons capacity and upwards are available.

Write to-day for full details.

Erected in minutes, the PORTASILO has unique advantages

★ No prepared foundations.
★ No power required for its operation.
★ No erection or dismantling problems.
★ No assembly joints to create trouble.

The system eliminates:

★ Unloading of cement by hand.
★ The need for a cement man behind the concrete mixer.
★ Waste.
★ The disposal of empty cement bags.

PORTASILO LIMITED

Covered by patent applications in Great Britain and the principal countries of the world.

BLUE BRIDGE LANE, YORK. *Telephone:* YORK 4872 (8 lines)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

Volume L, No. 4. LONDON, APRIL, 1955.

EDITORIAL NOTES

The Duplication of Information.

IN ethics and politics it is fairly true to say that there is nothing new under the sun. More than two thousand years ago it was written that history would always repeat itself because human nature would not change. Only the methods of making history change. The spear gives way to the gun and the bomb; mass crucifixions and other massacres are superseded by the gas chamber; but the reasons for war, their miseries, and the ends are the same as ever. Trackways give way to concrete roads, but the purpose of making it easier to get from place to place is the same. All the means used by man to make his life easier follow the pattern of invention and improvement, with periods of more or less standardisation between new ideas. This is true of making concrete as of men's other activities. Our present code of practice for reinforced concrete differs little in its fundamental requirements from the Rules issued by the Royal Institute of British Architects in 1907. Our knowledge of the requirements for making strong and durable concrete is no greater than it was a hundred years ago; only methods of doing the work have altered.

Since concrete roads were first used sixty or more years ago experience has led to the standardisation of their design for different conditions and for different volumes and types of traffic. This is the result of experience gained throughout the world in the design, construction, and performance of such roads and of experimental roads laid to compare the durability of reinforced and unreinforced slabs, the efficiency of different types of joints, the effect of different classes of traffic, varying thicknesses of slab, varying climatic conditions, and so on, on different formations. As the result of an investigation of concrete roads in Great Britain the technical director of the Cement and Concrete Association has been able to say that the problem of the structural stability of concrete roads is virtually solved, and that the remaining problems are in connection with the choice of the plant and equipment with which to do the work. That is to say, we have reached a period when practice is standardised, and generally will remain so until an entirely new conception is found to be as satisfactory, or better, or cheaper. For many years interested bodies in many countries have collected information relating to the performance of concrete roads, and this is all available to road authorities and engineers. This has not been done without a great deal of unnecessary expense due to similar tests being made at the same

time or at different times in different countries. It is indeed remarkable to see from reports and bulletins received from many countries that exactly the same research is often being done in more than one of them, and more remarkable still to see how often the same tests are made and the same results obtained in one country years after the same tests were made and the same results obtained in another. So often does this occur that it may be possible that members of research organisations with few ideas travel abroad to see what has been recently done so that they can go home and copy the same investigation and later publish the same results in different words.

It seems that the compilation of information on concrete roads is now to be further duplicated on a grand scale. For the benefit of less industrialised countries, where there is little or no experience of concrete roads and where there may be no bodies whose purpose it is to collect the results of future experience, the United Nations Organisation, through its Economic Commission for Asia and the Far East, has set up a committee, with headquarters in a palace in Bangkok, to collect and collate data relating to concrete roads already laid and to be laid in the countries with which the Commission is concerned. A questionnaire has been approved for this purpose. The instructions on the form-filling procedure comprise about 8000 words, and include a dissertation in which the engineer whose duty it would be to provide the information is told that " The main function of the road is for the movement of traffic ", " The essential requirement of any highway is to permit safe, efficient, and quick highway transportation at minimum cost ", and " Experience with actual traffic tests has been and is the most reliable basis for improvement ". These are indeed profound truths, but it seems unnecessary to suggest that there is so much difference in the intelligence of the administrators in the palace and the engineers on the site.

The questionnaire calls for replies to nearly two hundred questions, twelve maps and drawings, and the filling in of seven tables. This record would first be prepared by the man in charge of the road, from whom it would go to the next higher officer and to other still higher officers until it reached the chief engineer, and would then go back and forth through what is called a shuttlecock procedure. The compiling of this information on the site and its tabulation in Bangkok will obviously be a lengthy and tedious procedure, and there is little doubt that those who have to fill in this enormous questionnaire will be inclined to ask whether it is really necessary. There is already a great volume of information available on the design and construction and behaviour of concrete roads and their performance in all sorts of climates and on all kinds of soil which could be used by engineers in south-east Asia as it is elsewhere, and in any case the study of data, however voluminous, is no substitute for engineering knowledge and engineering sense.

As was mentioned at the beginning of this note, human nature does not change. Watching others work and noting their methods has always been an attraction to people of all ages. Records of methods and results are an essential factor in the progress of all arts and sciences, but the immense duplication of such records that is now going on in relation to subjects on which there is no need for secrecy is a waste of the time of many of those who provide the information and of those who tabulate it. Would it not be more helpful to road engineers in south-east Asia if they were provided with up-to-date standard works on the subject such as are already available?

Bending-moment Factors based on the Theory of Plastic Hinges.

By L. S. MÜLLER.

THE method of designing statically-indeterminate structures described by Dr. R. Gartner in "Concrete and Constructional Engineering" for January and February, 1953, may be shortened by the use of bending-moment factors. In this article continuous beams and slabs of equal spans, and with equal and symmetrically-applied loads, are considered. Bending-moment factors are tabulated, on the conception of plastic hinges, for uniformly-distributed load, a concentrated load at the centre of each span, and concentrated loads at the third-points of each span for continuous beams with two, three, four, and five equal spans. In order to show how the tables have been prepared, the factors for a beam of three equal spans with a uniformly-distributed superimposed load are derived in the following example. The notation is the same as in Dr. Gartner's article.

If the dead load $d = Kw$ and the superimposed load $l = (1 - K)w$, the maximum elastic bending moments at the internal supports are

$$-M_{B\,\text{max.}} = -(0{\cdot}1d + 0{\cdot}117l)L^2 = -\left(\frac{K}{10} + \frac{1-K}{8{\cdot}6}\right)wL^2;$$

or

$$-M_{B\,\text{max.}} = -\frac{7{\cdot}14 - K}{61{\cdot}4}wL^2.$$

The safe plastic bending moments at the same supports are assumed to be

$$-0{\cdot}7\frac{7{\cdot}14 - K}{61{\cdot}4}wL^2 = -\frac{7{\cdot}14 - K}{87{\cdot}8}wL^2 \quad . \quad . \quad . \quad (1)$$

The bending moment at the support used to calculate the maximum bending moment in the spans is

$$-M_B' = -M_B'' = -(0{\cdot}1d + 0{\cdot}05l)L^2 = -\left(\frac{K}{10} + \frac{1-K}{20}\right)wL^2$$

$$= -\frac{K+1}{20}wL^2 \quad . \quad . \quad . \quad (2)$$

By equating $-\frac{7{\cdot}14 - K}{87{\cdot}8}wL^2$ to $-\frac{K+1}{20}wL^2$, $K = 0{\cdot}51$; this value corresponds to the "hinge limit," that is, if K is less than $0{\cdot}51$, $\frac{K+1}{20}wL^2$ gives greater bending moment on the span and should be used; if K is more than $0{\cdot}51$ the safe plastic bending moment should be used. The factors tabulated are therefore calculated from $-\frac{20}{K+1}$ for values of K between 0 and $0{\cdot}5$, and from $-\frac{87{\cdot}8}{7{\cdot}14 - K}$ for values of K between $0{\cdot}51$ and 1.

METHOD OF USING TABLES (see pp. 151 to 153).—Calculate K from $\frac{d}{w}$ or $\frac{D}{W}$.

For uniformly-distributed loads: Read m_1 and calculate $+M_{1\,\max.}$ from $\frac{wL^2}{m_1}$ and m_2, and calculate $+M_{2\,\max.}$ from $\frac{wL^2}{m_2}$; read m_B and calculate $-M_{B\,\max}$ from $\frac{wL^2}{m_B}$ and m_B', and calculate $-M_B'$ from $\frac{wL^2}{m_B'}$, etc. For a concentrated load the bending moment $M = \frac{WL}{\text{factor}}$ where $W = D + L$ and is the total concentrated load acting at the centre or at one of the third-points.

Consider the floor shown in *Fig.* 1. The floor slab is continuous over four spans of 11 ft. The weight of the slab and floor finishes $(d) = 77$ lb. per square

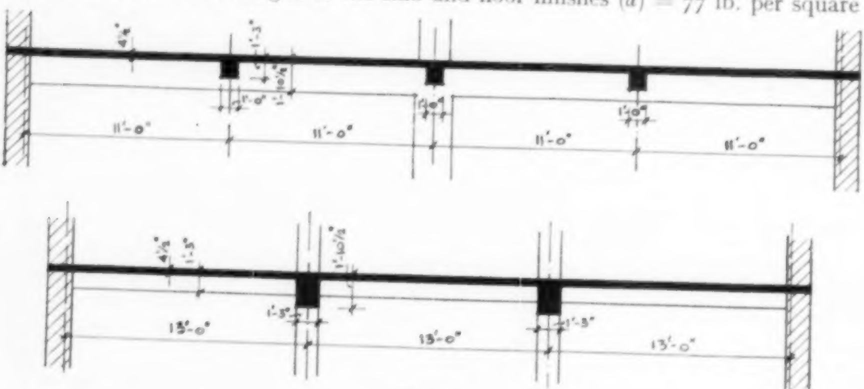


Fig. 1.

foot and the live load $(l) = 50$ lb. per square foot; the total load (w) is therefore 127 lb. per square foot, and $\frac{d}{w} = \frac{77}{127} = 0{\cdot}6$.

$$+M_{1\,\max.} = +\frac{127 \times 11^2}{11{\cdot}25} = 1370 \text{ ft.-lb.}; \quad +M_{2\,\max.} = +\frac{127 \times 11^2}{17{\cdot}55} = 880 \text{ ft.-lb.};$$

$$-M_{B\,\max.} = -\frac{127 \times 11^2}{12{\cdot}63} = -1220 \text{ ft.-lb.};$$

$$-M_{C\,\max.} + -\frac{127 \times 11^2}{16{\cdot}65} = -925 \text{ ft.-lb.}$$

The secondary beams are continuous over three spans of 13 ft.:

Load from slab $= 11 \times (77 + 50) = 846 + 550$
Weight of beam (12 in. $\times$ $10\frac{1}{2}$ in.) $= 129$

Total load $w =$ $975 + 550 = 1525$ lb. per foot.

$$\frac{d}{w} = \frac{975}{1525} = 0{\cdot}64.$$

$$+M_{1\,\max.} = +\frac{1525 \times 13^2}{11} = 23{,}600 \text{ ft.-lb.};$$

UNIFORMLY-DISTRIBUTED LOAD.

TWO EQUAL SPANS.

$K = d/\omega$	m_1 for $+M_{1max}$	m_B for $-M_{Bmax}$	m'_B for $-M'_B$
0·0	+10·45	−11·42	−16·00
0·1	+10·75		−14·55
0·2	+11·07		−13·33
0·3	+11·40		−12·30
0·4–1·0	+11·75		−11·42

THREE EQUAL SPANS.

$K = d/\omega$	m_1 for $+M_{1max}$	m_2 for $+M_{2max}$	m_B for $-M_{Bmax}$	m'_B for $-M'_B(-M''_B)$
0·0	+ 9·88	+13·33	−12·23	−20·00
0·1	+10·19	+14·28	−12·43	−18·18
0·2	+10·33	+15·38	−12·60	−16·63
0·3	+10·57	+16·67	−12·80	−15·38
0·4	+10·82	+18·18	−13·00	−14·28
0·5	+11·07	+20·00	−13·20	−13·33
0·51	+11·10	+20·20	−13·22	−13·22
0·6	+11·02	+20·00	−13·40	−13·40
0·7	+10·98	+19·40	−13·60	−13·60
0·8	+10·90	+18·93	−13·82	−13·82
0·9	+10·83	+18·60	−14·05	−14·05
1·0	+10·80	+18·20	−14·30	−14·30

FOUR EQUAL SPANS.

$K = d/\omega$	m_1 for $+M_{1max}$	m'_B for $-M'_B$	m_2 for $+M_{2max}$	m''_C for $-M''_C$	m_B for $-M_{Bmax}$	m_C for $-M_{Cmax}$
0·0	+ 9·96	−18·50	+12·40	−27·80	−11·80	−13·30
0·1	+10·28	−16·83	+13·14	−25·35	−11·93	−13·80
0·2	+10·53	−15·43	+13·96	−23·27	−12·05	−14·27
0·3	+10·80	−14·30	+14·87	−21·50	−12·20	−14·80
0·4	+11·07	−13·28	+15·92	−20·00	−12·35	−15·37
0·49	+11·33	−12·47			−12·47	
0·5	+11·33	−12·48	+17·23	−18·65	−12·48	−15·50
0·6	+11·25	−12·63	+17·55	−17·55	−12·63	−16·65
0·65	+11·22	−12·75	+17·60	−17·05	−12·75	−17·05
0·7	+11·20	−12·81	+17·40	−17·40	−12·81	−17·40
0·8	+11·15	−12·99	+16·97	−18·20	−12·99	−18·20
0·9	+11·11	−13·15	+16·43	−19·05	−13·15	−19·05
1·0	+11·02	−13·30	+16·00	−20·00	−13·30	−20·00

FIVE EQUAL SPANS.

$K = d/\omega$	m_1 for $+M_{1max}$	m'_B for $-M'_B$	m_2 for $+M_{2max}$	m''_C for $-M''_C$	m_3 for $+M_{3max}$	m_B for $-M_B max$	m_C for $-M_C max$
0·0	+10·00	−18·82	+12·63	−25·65	+11·63	−11·90	−12·87
0·1	+10·24	−17·17	+13·45	−23·25	+12·20	−12·05	−13·25
0·2	+10·45	−15·77	+14·33	−21·25	+12·80	−12·20	−13·65
0·3	+10·72	−14·57	+15·35	−19·60	+13·50	−12·35	−14·05
0·4	+11·00	−13·53	+16·46	−18·15	+14·27	−12·50	−14·55
0·5	+11·23	−12·67	+17·83	−16·95	+15·17	−12·67	−15·02
0·6	+11·20	−12·85	+18·28	−15·85	+16·18	−12·83	−15·58
0·62		−12·88	+18·30	−15·65	+16·40	−12·88	−15·65
0·7	+11·15	−13·02	+17·87	−16·18	+15·85	−13·02	−16·18
0·8	+11·08	−13·21	+17·40	−16·78	+15·25	−13·21	−16·78
0·9	+11·02	−13·40	+16·97	−17·40	+14·80	−13·40	−17·40
1·0	+10·97	−13·60	+16·42	−18·10	+14·55	−13·60	−18·10

Bending Moments with Plastic Hinges.

CONCENTRATED LOADS AT THE CENTRE OF THE SPANS.

TWO EQUAL SPANS.

K – D/W	m_1 for $+M_{1max}$	m_B' for $-M_B'$	m_B for $-M_{Bmax}$
0·0	+4·91	−10·62	
0·1	+5·03	−9·67	
0·2	+5·17	−8·86	−7·60
0·3	+5·29	−8·18	
0·4–1·0	+5·42	−7·60	

THREE EQUAL SPANS.

K – D/W	m_1 for $+M_{1max}$	m_2 for $+M_{2max}$	m_B' for $-M_B'(M_B'')$	m_B for $-M_{Bmax}$
0·0	+4·70	+5·71	−13·33	−8·17
0·1	+4·78	+5·97	−12·13	−8·30
0·2	+4·86	+6·23	−11·13	−8·41
0·3	+4·96	+6·53	−10·25	−8·53
0·4	+5·06	+6·89	−9·53	−8·67
0·5	+5·15	+7·25	−8·90	−8·80
0·51	+5·17	+7·31	−8·81	−8·81
0·6	+5·15	+7·23	−8·93	−8·93
0·7	+5·12	+7·13	−9·09	−9·09
0·8	+5·10	+7·03	−9·22	−9·22
0·9	+5·08	+6·97	−9·38	−9·38
1·0	+5·07	+6·88	−9·52	−9·52

FOUR EQUAL SPANS.

K – D/W	m_1 for $+M_{1max}$	m_B' for $-M_B'$	m_2 for $+M_{2max}$	m_C'' for $-M_C''$	m_B for $-M_{Bmax}$	m_C for $-M_{Cmax}$
0·0	+4·76	−12·50	+5·46	−18·45	−7·90	−8·88
0·1	+4·84	−11·38	+5·66	−16·82	−8·00	−9·20
0·2	+4·95	−10·40	+5·90	−15·42	−8·09	−9·52
0·3	+5·04	−9·59	+6·12	−14·28	−8·17	−9·88
0·4	+5·16	−8·90	+6·38	−13·27	−8·27	−10·23
0·5	+5·26	−8·36	+6·67	−12·40	−8·36	−10·67
0·6	+5·25	−8·46	+6·75	−11·65	−8·46	−11·13
0·65		−8·52	+6·80	−11·33	−8·52	−11·33
0·7	+5·22	−8·57	+6·72	−11·60	−8·57	−11·60
0·8	+5·19	−8·68	+6·60	−12·15	−8·68	−12·15
0·9	+5·17	−8·77	+6·50	−12·73	−8·77	−12·73
1·0	+5·16	−8·88	+6·38	−13·35	−8·88	−13·35

FIVE EQUAL SPANS.

K – D/W	m_1 for $+M_{1max}$	m_B' for $-M_B'$	m_2 for $+M_{2max}$	m_C'' for $-M_C''$	m_3 for $+M_{3max}$	m_B for $-M_{Bmax}$	m_C for $-M_{Cmax}$
0·0	+4·75	−12·65	+5·51	−16·98	+5·23	−7·99	−8·57
0·1	+4·83	−11·50	+5·73	−15·40	+5·40	−8·08	−8·82
0·2	+4·92	−10·55	+5·97	−14·13	+5·58	−8·18	−9·10
0·3	+5·02	−9·73	+6·23	−13·02	+5·77	−8·28	−9·40
0·4	+5·13	−9·04	+6·50	−12·12	+5·97	−8·38	−9·70
0·5	+5·23	−8·49	+6·80	−11·30	+6·19	−8·49	−10·03
0·6	+5·20	−8·59	+6·89	−10·60	+6·42	−8·59	−10·40
0·62		−8·60	+6·92	−10·45	+6·48	−8·60	−10·45
0·7	+5·19	−8·70	+6·82	−10·78	+6·37	−8·70	−10·78
0·8	+5·17	−8·81	+6·72	−11·20	+6·22	−8·81	−11·20
0·9	+5·15	−8·93	+6·61	−11·63	+6·10	−8·93	−11·63
1·0	+5·12	−9·05	+6·50	−12·13	+5·97	−9·05	−12·13

Bending Moments with Plastic Hinges.

CONCENTRATED LOADS AT THE THIRD-POINTS OF THE SPANS.

TWO EQUAL SPANS.

K = D/W	m_1 for $+M_{1max}$	m_B' for $-M_B'$	m_B for $-M_{Bmax}$
0·0	−3·60	−6·00	
0·1	−3·67	−5·45	
0·2	−3·75	−5·00	−4·27
0·3	−3·84	−4·61	
0·4−1·0	−3·92	−4·27	

THREE EQUAL SPANS.

K = D/W	m_1 for $+M_{1max}$	m_2 for $+M_{2max}$	m_B' for $-M_B'$	m_B for $-M_{Bmax}$
0·0	+3·46	+5·00	−7·50	−4·57
0·1	+3·51	+5·37	−6·81	−4·64
0·2	+3·57	+5·77	−6·25	−4·70
0·3	+3·63	+6·23	−5·77	−4·77
0·4	+3·69	+6·81	−5·35	−4·84
0·5	+3·75	+7·50	−5·00	−4·92
0·52	+3·76	+7·63	−4·94	−4·94
0·6	+3·75	+7·50	−5·00	−5·00
0·7	+3·74	+7·35	−5·07	−5·07
0·8	+3·72	+7·20	−5·15	−5·15
0·9	+3·71	+7·01	−5·23	−5·23
1·0	+3·70	+6·88	−5·32	−5·32

FOUR EQUAL SPANS.

K = D/W	m_1 for $+M_{1max}$	m_B' for $-M_B'(-M_B'')$	m_2 for $+M_{2max}$	m_C'' for $-M_C''$	m_B for $-M_{Bmax}$	m_C for $-M_{Cmax}$
0·0	+3·50	−6·97	+4·50	−10·53	−4·45	−4·98
0·1	+3·57	−6·33	+4·75	−9·55	−4·50	−5·16
0·2	+3·63	−5·81	+5·00	−8·76	−4·54	−5·34
0·3	+3·69	−5·36	+5·30	−8·09	−4·59	−5·53
0·4	+3·76	−4·97	+5·64	−7·50	−4·65	−5·75
0·49	+3·82	−4·69			−4·69	
0·5	+3·81	−4·70	+5·98	−7·01	−4·70	−5·88
0·6	+3·80	−4·76	+6·19	−6·57	−4·76	−6·22
0·65		−4·78	+6·28	−6·37	−4·78	−6·37
0·7	+3·79	−4·82	+6·18	−6·51	−4·82	−6·51
0·8	+3·78	−4·87	+5·99	−6·80	−4·87	−6·80
0·9	+3·76	−4·93	+5·80	−7·12	−4·93	−7·12
1·0	+3·75	−4·99	+5·63	−7·50	−4·99	−7·50

FIVE EQUAL SPANS.

K = D/W	m_1 for $+M_{1max}$	m_B' for $-M_B'$	m_2 for $+M_{2max}$	m_C'' for $-M_C''$	m_3 for $+M_{3max}$	m_B for $-M_{Bmax}$	m_C for $-M_{Cmax}$
0·0	+3·49	−7·10	+4·63	−9·50	+4·37	−4·49	−4·81
0·1	+3·55	−6·45	+4·90	−8·63	+4·62	−4·54	−4·95
0·2	+3·61	−5·91	+5·20	−7·91	+4·83	−4·60	−5·10
0·3	+3·67	−5·46	+5·52	−7·30	+5·10	−4·65	−5·27
0·4	+3·74	−5·07	+5·90	−6·78	+5·38	−4·70	−5·44
0·49	+3·80	−4·76	+6·30	−6·37	+5·68	−4·76	−5·61
0·5	+3·80	−4·76	+6·33	−6·33	+5·70	−4·76	−5·62
0·6	+3·79	−4·82	+6·60	−5·93	+6·05	−4·82	−5·82
0·62	+3·78	−4·84	+6·63	−5·86	+6·12	−4·84	−5·86
0·7	+3·77	−4·88	+6·48	−6·03	+5·98	−4·88	−6·03
0·8	+3·76	−4·95	+6·27	−6·27	+5·74	−4·95	−6·27
0·9	+3·75	−5·01	+6·09	−6·50	+5·58	−5·01	−6·50
1·0	+3·73	−5·09	+5·90	−6·77	+5·39	−5·09	−6·77

Bending Moments with Plastic Hinges.

$$+M_{2\,max.} = +\frac{1525 \times 13^2}{19 \cdot 76} = 13{,}100 \text{ ft.-lb.};$$

$$-M_{B\,max.} = -\frac{1525 \times 13^2}{13 \cdot 48} = -19{,}300 \text{ ft.-lb.}$$

The main beams are continuous over two spans of 22 ft. each :

$$\begin{aligned} \text{Load from secondary beams} &= 13 \times (975 + 550) = 12{,}675 + 7150 \\ \text{Weight of beam} &= (15 \text{ in.} \times 18 \text{ in.} \times 11 \text{ ft.}) = 3{,}100 \\ \text{Total load } W &= \\ &= 15{,}775 + 7150 = 22{,}925 \text{ lb.} \end{aligned}$$

$$\frac{D}{W} = \frac{15{,}775}{22{,}925} = 0 \cdot 69.$$

$$+M_{1\,max.} = +\frac{22{,}925 \times 22}{5 \cdot 42} = 93{,}000 \text{ ft.-lb.};$$

$$-M_{B\,max.} = -\frac{22{,}925 \times 22}{7 \cdot 6} = -66{,}400 \text{ ft.-lb.}$$

"Concrete and Constructional Engineering" Prize Design.

THE prize awarded by the proprietors of "Concrete & Constructional Engineering" annually for competition among the students at the Department of Concrete Technology of the Imperial College of Science and Technology, London, has been awarded to Mr. H. H. Tsou for the year 1953–1954. The designs submitted by Mr. W. S. Rindl and Mr. A. K. E. Labib were highly commended. The assessor was Mr. W. K. Wallace, C.B.E., M.Inst.C.E.

The subject of the competition, set by Professor A. L. L. Baker, was the re-planning of the area bounded by London Bridge, Tower Bridge, Eastcheap, and Tower Hill, which contains Billingsgate fish market. Buildings of historic interest were to be preserved and if possible isolated, and new buildings sited in relation to them to produce as far as possible a satisfactory grouping. The general aim was to be better lighting in the buildings, wider roads, and an absence of traffic congestion. A new road bridge for four lines of vehicles over the river had to be included. Jetties and wharves to suit the anticipated future river traffic were to be provided. The plan had to be indicated by an outline plan and cross section, and only the general arrangement of each type of structure need be drawn, for example, a typical warehouse and office block, a fish market, a jetty-wharf and approaches, and a bridge over the river. The supporting capacity of the ground was to be assumed from site inspection, geological survey data, and any other available information.

So far as possible the students worked in groups of three to six, and collaborated in the planning and the design of each structure. Each student had to undertake the design of at least one structure, and students who undertook a prestressed concrete design had also to carry out a reinforced concrete design in order to qualify for the Diploma of the Imperial College.

In addition to drawings, competitors had to produce sufficient calculations to indicate that the detailed design of each type of member in each structure was fully understood, a report giving the reasons for the general arrangement of the site and the structural system adopted for each main structure detailed, and an estimate of the cost of the engineering work of each main structure detailed.

Mr. Tsou's winning design was for a bridge, Mr. Rindl's design was for a fish market, and Mr. Labib's design was for a multiple-story garage.

Prestressed Concrete Bridges.*

By DONOVAN LEE, M.Inst.C.E.

For road bridges the use of prestressed concrete has increased so rapidly that in many countries it is likely soon to become exceptional to use other materials, at any rate for spans up to at least 100 ft. The reason is the combination of low initial cost and expected very low depreciation. High-grade "crackless" concrete is expected to have a durability and absence of maintenance cost that, capitalised, may result in a saving of up to 25 per cent. for an assumed useful life of fifty years if the alternative material requires expenditure on maintenance. However, to achieve low initial cost and low depreciation more care should be given to details than is often the case. It is true that post-tensioned prestressed concrete is initially tested by the tensioning of the bars or cables, but this is a proof of initial strength only and generally gives no indication of durability. For railway bridges this applies with greater emphasis.

Materials.

The usually-accepted minimum 28-days' cube strength of concrete suitable for prestressing is 6000 lb. per square inch. Lower strengths can be used, particularly when the steel is post-tensioned; for example, the lowest strength permitted by the German code is 4280 lb. per square inch (see this Journal for June 1954), but usually it is not economical. The minimum cement content permitted by the Report on Prestressed Concrete of the Institution of Structural Engineers is 550 lb. per cubic yard of concrete when the steel is post-tensioned and 630 lb. when the steel is pre-tensioned. Perhaps the most common causes of the strength of concrete falling below that specified are insufficient compaction, failure to allow for the variable water content in the sand, and occasionally the slow hardening of the cement; the last is generally not important as the normal strength is only delayed.

As regards compaction, it is still often overlooked that 5 per cent. of air in the concrete will generally lower the strength by 30 per cent. and it is important that all of the concrete be completely vibrated. Supervision while the concrete is being placed should be continuous. It is generally not necessary to use rapid-hardening cement; in post-tensioned work particularly it is better to use ordinary Portland cement, although rapid-hardening cement may be used in order to save time provided that allowance is made for the greater shrinkage stresses. The error should be avoided of assuming that the results of cube tests denote the strength of the concrete in the structure.

The water-cement ratios mostly used are between 0·38 and 0·45; it is usually best that the water-cement ratio be not lower than is necessary to obtain the required strength with a small margin, but care must be taken to ensure that the quality of the concrete and the compaction are of the standard required throughout. On the whole, concretes containing crushed aggregate need more care in compaction than those containing natural rounded aggregate; also, gap-graded mixtures seem to compact more quickly by vibration.

The steel for prestressing should have a fairly high strength to enable the working stress to be high enough to reduce to a small proportion the loss of stress in the steel due to creep and shrinkage of the concrete. However, earlier emphasis on the highest possible tensile stress in the steel is now known to be pointless, as the ultimate strength of prestressed concrete is not affected by loss of stress in the steel due to creep and shrinkage. Further, with lower working stresses in the steel the deflection, with loads higher than those causing cracks, does not increase as fast as when there are higher stresses in the steel (assuming that E for both the steels and concretes are equal); thus under excessive load the performance is better at no more cost. Relaxation, or creep, of the steel reduces only the active prestress, and therefore the cracking load.

Road Bridges.

Prestressed concrete is normally very economical for spans up to well over 120 ft., but more experience is needed before attempting to generalise on the

* Condensed from a paper read at the Symposium on Prestressed Concrete, Hyderabad, February, 1955.

minimum span at which the lighter weight of steel-lattice girders and deck framing enables structural steel to be the more economical material. For small spans, say, up to 20 ft., where the deck can span longitudinally without main beams, there is generally some saving of materials by prestressing, but costs are so much affected by other considerations that reinforced concrete may be cheaper in one case and prestressed concrete in another. Generally speaking, for spans between

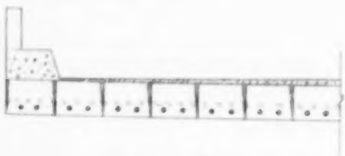


FIG 1(a)

FIG 1(b)

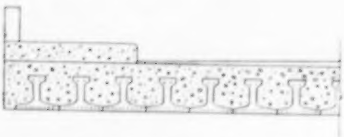


FIG 2

FIG 3(a)

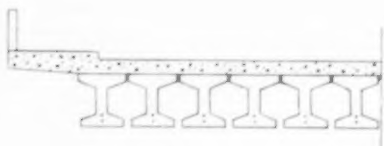


FIG 3(b)

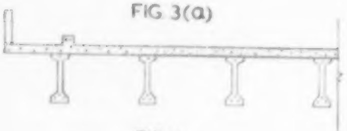


FIG 4

FIG 5(a)

FIG 5(b)

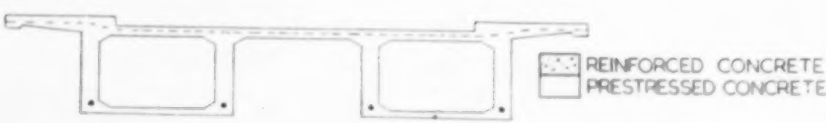


FIG 6

Types of Prestressed Road Bridges.

Fig. 7.—"Ten-miles" Road Bridge, Oregon, U.S.A.

25 ft. and 120 ft. it is not likely that reinforced concrete will be cheaper than prestressed concrete, but over 100 ft., where there is also ample depth for an arch, a reinforced concrete structure, particularly of the open-spandrel type, is one of the few alternatives that may be more economical.

Whether it is cheaper to precast or cast in place does not necessarily depend upon the span; it primarily depends upon the cost of the falsework needed for cast-in-place work compared with the possible economy of precasting when the amount of repetition is reasonably large.

Fig. 8.—Teven Bridge, N.S.W.: One Bar Tensioned; Others to be Tensioned later to provide Continuity.

For spans from 20 ft. upward, disregarding special types and some types with exceptional economic justification, *Figs.* 1 to 6 show the types of road bridge most likely to be cheapest for average conditions in Great Britain; this is fairly correct also for countries with widely differing costs of labour and materials.

The types shown in *Figs.* 1(a) and 2 are generally applicable for spans up to about 35 ft., and are very seldom economical for longer spans. The steel may be pre-tensioned or post-tensioned. They are particularly suitable where a shallow depth of construction is needed, or where strutting underneath would be inconvenient, as over railway tracks. The type shown in *Fig.* 1(b) is also suitable for shallow construction depths, but may be economical for spans up to about 60 ft. where staging can be provided at low cost.

The construction shown in *Fig.* 3(a) has been used extensively, and is useful for spans from about 40 ft. to 80 ft., or greater when they are made continuous. The beams are frequently cast adjoining the site, and this method should be considered where repetition is appreciable. *Fig.* 3(b) shows a method used for somewhat shorter spans where headroom is limited but for longer spans than types 1 and 2.

The construction shown in *Fig.* 4 can be very economical where headroom is not

Fig. 9.—Lower Tampa Bay Bridge, Florida, U.S.A. A Prestressed Section Two Miles Long is seen in the Distance.

Fig. 10.—Bridge at Coblenz being Built with Cantilevered Shuttering.

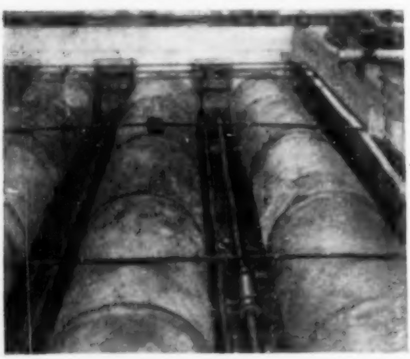


Fig. 11.—Footbridge of 75-ft. Span for Lee Conservancy Catchment Board.

limited, and particularly where several equal spans of about 40 ft. to 80 ft. are needed. The beams are designed to carry the wet concrete of the slab, which then acts compositely with the beams to carry subsequent loads. As the span increases the beams are spaced farther apart, and the span of the deck increased so that type 5(a) is used for spans of up to 120 ft. or more. The method shown in *Fig.* 5(b) is suitable for relatively narrow bridges of single spans from 50 ft. to over 100 ft., where the provision of full staging is not difficult.

Box girders (*Fig.* 6) are also used for longer spans cast in place, but the extra shuttering required may make it more economical to provide separate bottom flanges to the webs.

Figs. 7, 8, and 9 show road bridges with prestressed precast beams and cast-in-place decks. *Fig.* 10 shows a cast-in-place road bridge in Germany built by the cantilevering method (see this journal for August, 1953). *Fig.* 11 shows a cast-in-place slab-type bridge with voids formed by precast concrete pipes to give the equivalent of I-section prestressed beams with smooth top and bottom surfaces. It is becoming more usual now to form voids of this type by means of waxed-cardboard or sheet-metal tubes; care is needed, however, not to

damage the tubes during internal vibration of the concrete.

A comparison of bridge loadings is given in *Fig.* 12. The British Ministry of Transport has a higher loading than the standard shown for bridges liable to exceptional loads; the curve for the Indian Class A loading is therefore to be compared with the Ministry of Transport's standard loading. As an example of U.S.A. practice, the H15 loading was used for the design of the Lower Tampa

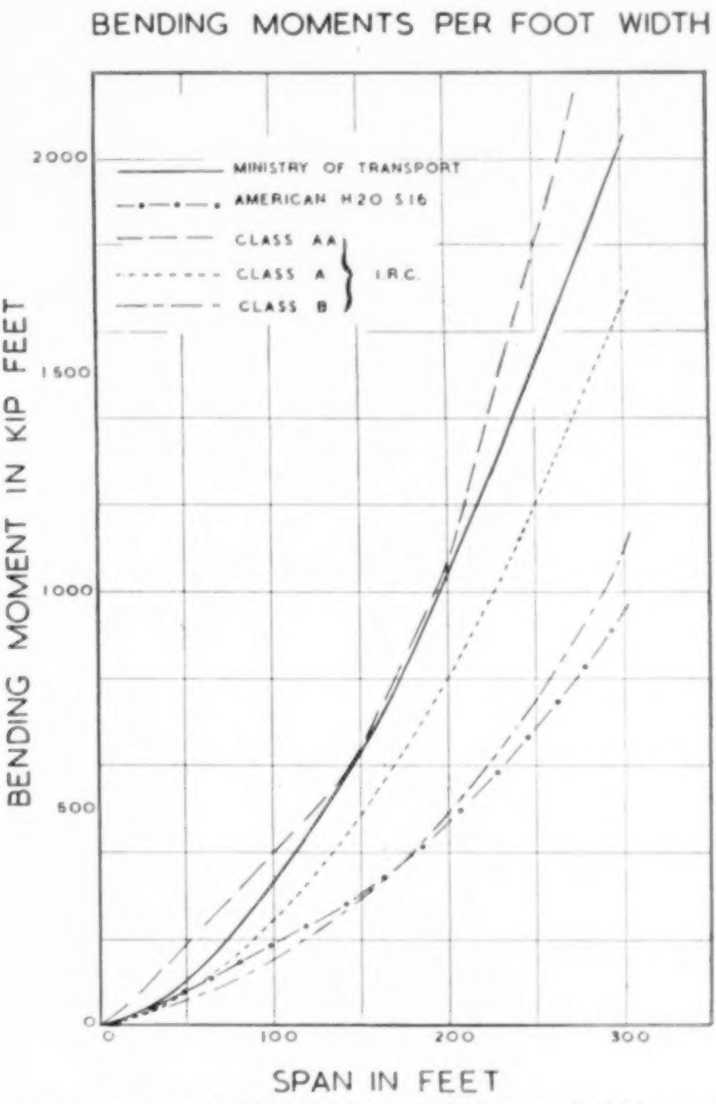


Fig. 12. Comparison of British, U.S.A., and Indian specified Live Loadings for Bridges.

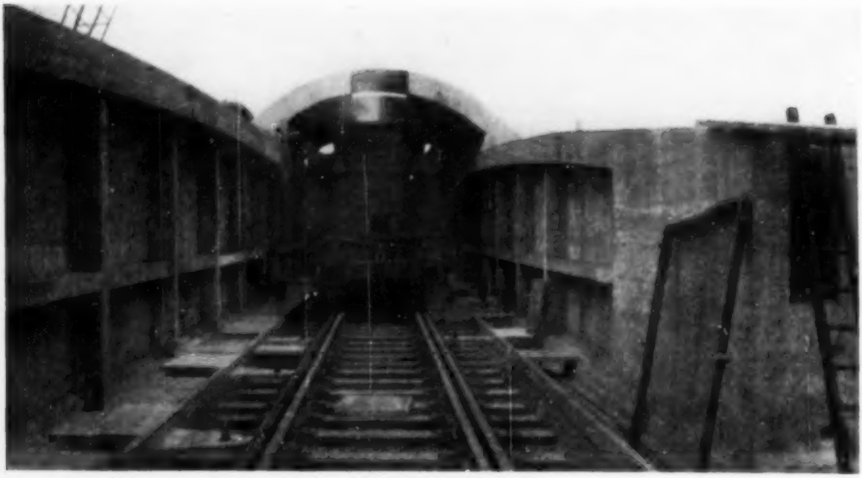


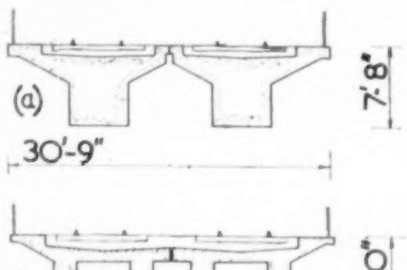
Fig. 13.—Underline Bridge at Rotherham : 160 ft. Span.

Bay bridge (*Fig.* 9), but the design was checked to ensure that the H20-S16 loading would not cause excessive stresses.

Railway Bridges.

The largest underline railway span constructed to date in Great Britain is the bridge of 160-ft. span at Rotherham (*Fig.* 13). At least fifty bridges partly or wholly of prestressed concrete are in progress or already built on British and German railways; most of the British bridges are prestressed with high-tensile alloy steel bars. It appears that both in Great Britain and Germany the use of prestressed concrete for railway bridges has proved so satisfactory that there is no hesitation in using prestressed concrete wherever the conditions are suitable. These opportunities, however, are not so extensive as might at first appear, as in Great Britain at any rate bridges now being built are mostly renewals of existing bridges and in many cases other forms of construction are more suitable. *Figs.* 14(a), (b), and (c) show cross sections of some recent prestressed underline bridges in Germany.

In the case of the bridge at Rotherham (see this Journal for January, 1953) the high flood-level of the river required the main girders to be above the tracks and the deck to be suspended from the girders. This bridge is on a skew of 58½ deg. and is designed for greater than normal main-line loading. It would be almost impossible with structural steel to have



(a) Spans of 65 ft. and 82 ft. (b) Span 70 ft. (c) Span 69 ft. 9 in.

Fig. 14.—Types of recent German Underline Bridges.

obtained such a small depth of construction with ballasted track (the deck slab is only 10½ in. thick), while with reinforced concrete the depth would have been at least double with girders spaced 17 ft. 6 in. apart. Experience gained suggests that with the normal type of construction [as in *Fig.* 14(b)], with prestressed beams under the tracks, prestressed concrete should be competitive in cost with steel up to a somewhat greater span, and the benefit of reduced maintenance would still enable an advantage in cost to be shown in average conditions for spans up to nearly 200 ft. In the case of Ederstrom bridge in Germany [*Fig.* 14(a)], separate bridges were built side by side each carrying a single track, and the writer would recommend this method generally in preference to designing for the incidence of the live load which is otherwise necessary. It seems doubtful whether the method used in this case of having a single wide supporting beam would be repeated

FIG.15(a)

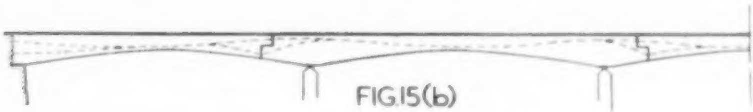


FIG.15(b)

FIG.16(a)

FIG.16(b)

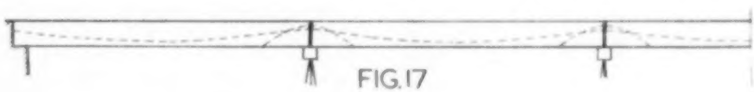


FIG.17

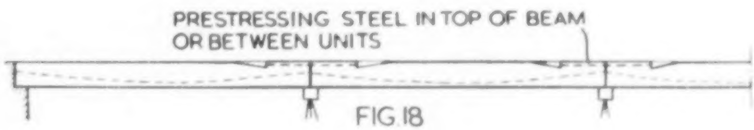


FIG.18

FIG.19

Types of Bridges with Continuous Beams.

owing to the experience obtained with the heating of the concrete, a temperature rise at the centre of 20 deg. C. having been found at one time. Also, the torsional stresses in the event of a derailment would discourage the writer from considering this type of cross section to be comparable with that shown in *Fig.* 14(b).

Bridges with Continuous Beams.

Continuity in prestressed concrete is not used as much relatively as in reinforced concrete. The reason is that generally it necessitates some additional stressing procedure, and the extra cost in the case of small spans often more than offsets the economy, if any, of the material. In other cases the advantage of simply-supported spans, where it cannot be certain that there will be no relative settlement of the supports, tends to favour simple spans. Too much importance need not perhaps be paid to relative settlement, but the use of plastic hinges may impair the durability if cracking occurs. In many cases continuity does not in fact result in any saving of material. This is particularly true in the case of continuous beams of equal span, in which the range of moment-variation due to live load is exactly the same at the centre of the span whether it is continuous or not, but some saving can generally be made when some of the spans are short and others long. Portal-frame bridges, when the legs are relatively short, are an example where economy may be made, but these can be used only where there is no possibility of yielding of the foundations.

In prestressed members the dead loads, where they do not exceed a certain proportion of the live load, are usually carried by increasing the eccentricity of the prestressing force. In longer simply-supported bridges it is not always possible to do so completely, and so a slight saving of material can generally be obtained in spans over about 70 ft., increasing as the span increases, by making the bridge continuous. This enables about 85 per cent. of the dead load to be carried on much greater spans without additional steel. Continuity is therefore most useful for bridges when the foundation or substructure is relatively expensive.

To avoid extra prestressing operations, and at the same time avoid the effects of possible relative settlement of the piers, arrangements of spans as in *Fig.* 15(a) and (b) are recommended. The loss due to friction is seldom more than 5 per cent. of the initial tensile stress in the steel, and as it does not reduce the ultimate strength it is not necessary, and generally undesirable, to offset it by an increase of the initial tension applied by the jack. The reverse moment at mid-span with adjacent spans loaded is frequently critical and limits the length of the cantilevers. For the lower Tampa Bay bridge (*Fig.* 9), where in one section there are 227 spans of 48 ft., the incidence of the live load together with the cost of the extra stressing operations nullified the possibility of a saving by continuity. Alternate long and short spans would, of course, have greatly favoured continuity; if the foundation and sub-structure had been expensive the economical span would have been larger, and this would have favoured continuity even with equal spans. In the case of the Mahi bridge in India now under construction, in which there are 16 spans of 110 ft., continuity was also not considered an advantage.

Many bridges have been made continuous by prestressing over the full length as in *Fig.* 16(a) and (b), but in these cases friction may be appreciable. These bridges are either cast in place or precast in lengths, and often jointed at points of minimum bending moment with only a part of the steel extending the full length as in (b). Using continuous steel through all the spans raises the question of friction and necessitates a constant prestressing force over the whole length. It also normally requires that the whole bridge be prestressed in one operation, thereby preventing successive prestressing of spans and re-use of staging, but the method has been used in Germany for a number of multiple-span bridges. Other ways of obtaining continuity (*Figs.* 17, 18, and 19) apply to beams made continuous after they are completed and are carrying their own weight as simply-supported beams. It is, of course, possible for a multiple-span bridge to be continuous in respect of live load only, as the recently-completed Northam bridge at Southampton*, or continuous as regards the live load and also the deck slab, depending on the time at which the jointing and prestressing

* Proc. Inst.C.E., Part 1, Vol. 4, May 1955.

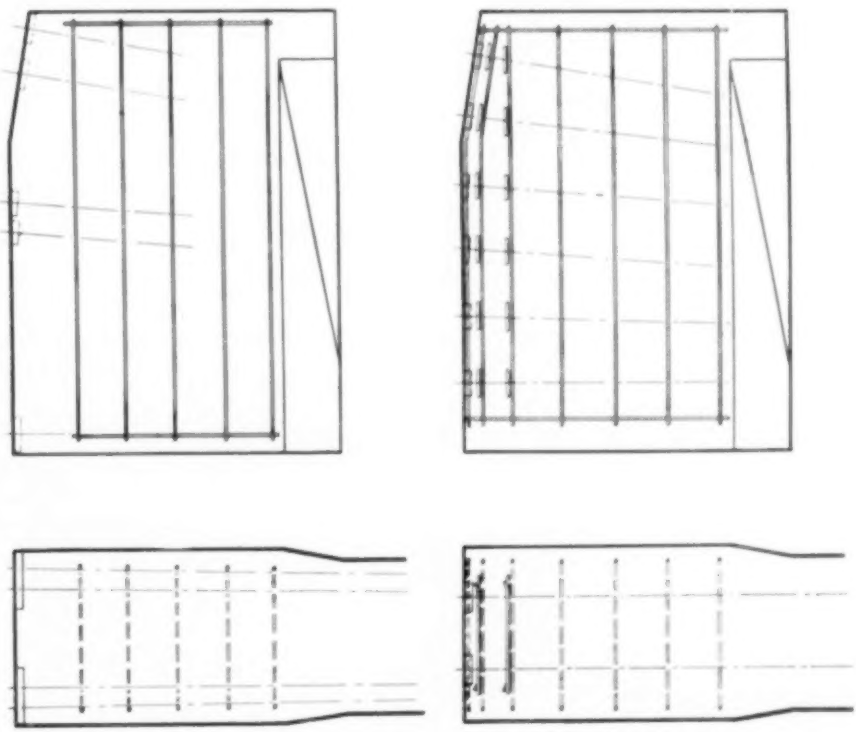
over the supports are done and the restraint moment applied.

On the whole these methods have not been used very much for bridges. The designs shown in *Figs.* 17 and 18 suffer from the need for extra site work in prestressing, and with the method shown in *Fig.* 17 it is often inconvenient to tension the steel from underneath; also, unless slipping of the wires can be prevented, it is difficult in such short lengths to apply with certainty the precise amount of prestress desired. The use of bars in place of wedge-gripped wires avoids uncertainty about the exact prestress applied, as there is no slipping when the nuts are screwed tight, but it is an extra prestressing operation and is usually not worth while for short spans.

The foregoing is not intended to discourage the use of continuous bridges, but merely to indicate points that should not be overlooked before deciding one way or the other.

Details of Construction.

For preference the prestress should be applied more or less evenly over the end section as in *Fig.* 20(b) and not as in *Fig.* 20(a). The reinforcement in the end-block should enclose the end-plates as at (b) and not be behind them as at (a); also the cage should be tied across in the case of deep narrow beams as indicated at (b). The arrangement at the end of a beam as in *Fig.* 20(a), where the steel is at the bottom of the section, is not so good as at (b) where all the steel is near to the vertical centre line. Apart from the need in case (a) of reinforcement to prevent the bottom corners from being liable to split off when the prestressing force is applied, if there is any slight error in the position of the steel or the quality of the concrete



(a).—Incorrect. (b).—Correct.

Fig. 20.—Details of End Blocks.

and the bars are closer together as in (b) there will be less risk of eccentric lateral stressing when both bars are non-uniformly tensioned simultaneously. Sometimes also it enables successive partial tensioning using only one jack. The end plates must be square (that is normal to the steel), and to achieve this it is usual to fix the end-plates to the end shutter and securely locate the ducts by wire or mild steel reinforcement at 2 ft. or 3 ft. from the end of the beam.

When couplers are used they are placed in enlarged sections of the ducts, and space is left for movement of the coupler when tensioning the bar. Although the coupler-boxes are later filled with cement when the duct is grouted, they decrease the section of the concrete where they occur, so are usually placed slightly away from the position of maximum bending moment, which may be at midspan, and in beams having many bars couplers are arranged so that not more than two occur at any point. A coupler-box is shown in *Fig.* 11.

Grouting is done, after the steel has been tensioned, through the bolt-holes in one of the end-plates, the bolt having been removed when the shutter is taken away. The sheath end-piece shown in *Fig.* 21 forms a connection with the duct, and entry of water or cement into the duct through the joint during vibration of the concrete is prevented by sealing the joint with adhesive tape or a paste such as putty or white lead. It is essential that the steel be fully protected and that the end anchorages be adequately encased. This is usually done by leaving some mild steel projecting from the ends of the beams and, after tensioning the bars and grouting the ducts, the surplus thread is cut off.

To distribute the live load and avoid overstressing the deck slab and any finishes, bridge beams are usually provided with diaphragms and a transverse prestress at intervals along their length. How much transverse resisting moment should be provided is not generally agreed, and there are no accepted rules on the spacing of the diaphragms. Experience suggests the detail shown in *Fig.* 22 is quite inadequate, even if the reinforcement of the deck slab were arranged to resist also the negative bending moments, but the detail shown in *Fig.* 23 is normal practice. For square spans the spacing used for the Tampa Bay bridge (*Fig.* 24) is typical, but could be increased for a bridge carrying a single line of traffic where the transverse moment can never be large. The diaphragms are sometimes precast but more often cast in place, the ducts being left in and the bars being placed in them before concreting is commenced. In narrow bridges to carry a single line of traffic reinforced concrete diaphragms are generally adequate and more economical. A cast-in-place reinforced concrete deck slab has been generally found most economical in Great Britain for road bridges with spans up to 70 ft. if the width is less than 30 ft. If the span is greater than 70 ft. and the width about 30 ft., the tendency is to space the main beams farther apart; in such cases it is possible, due to the saving in dead weight, that a prestressed deck

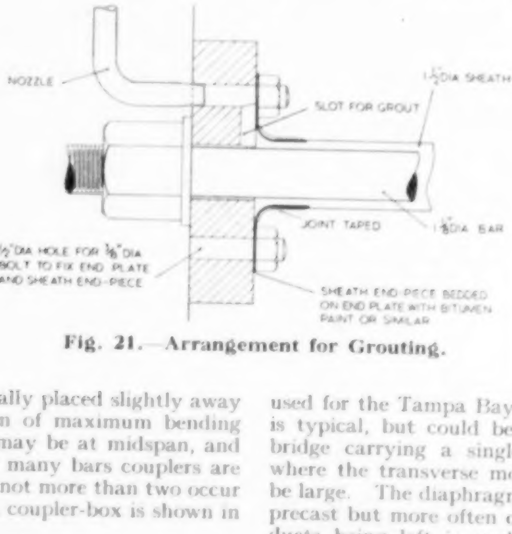


Fig. 21.—Arrangement for Grouting.

will give some economy. In the case of railway bridges prestressed decks are normally economical for any width; a cross section through the bridge at Rotherham (previously mentioned) is shown in *Fig. 25*.

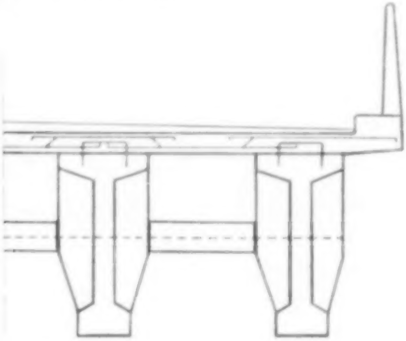
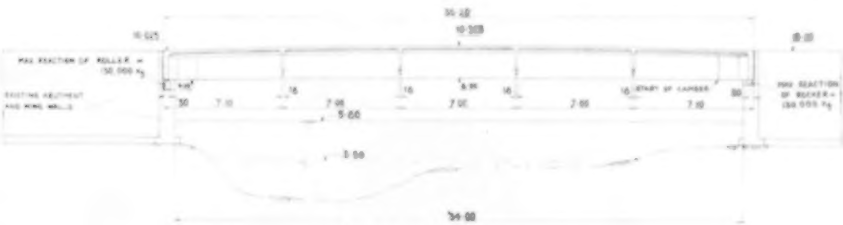


Fig. 22.—Inadequate Provision of Transverse Stiffening.

When flexible metal ducts are left in the concrete, as is usual, some fixing is necessary in both the vertical and horizontal directions to ensure that they do not move during vibration of the concrete and to maintain the correct curvature of inclined ducts.

Grouting.

If loss of prestress is to be reduced by retensioning the bars, grouting must be postponed, but the advantage of re-tensioning is not often worth while. The grout is usually colloidal cement, or neat cement with a water-cement ratio about 0·5 or, if a plasticiser or a wetting agent is used, the water-cement ratio may be lower. Strong grout is not essential, as the bond stresses are usually very low at design loading, but high-strength grout can slightly increase the ultimate strength of the member. The pressure should normally not exceed about 30 lb. per



Dimensions in Metres.

Fig. 23.—Spacing of Transverse Diaphragms for a Road Bridge in Colombia.

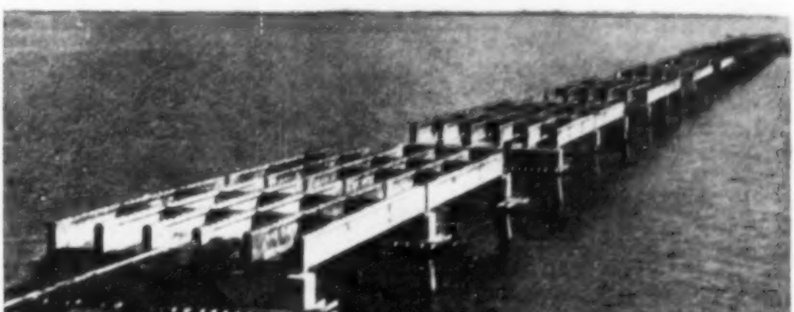


Fig. 24.—Example of Transverse Diaphragms (Tampa Bay Bridge).

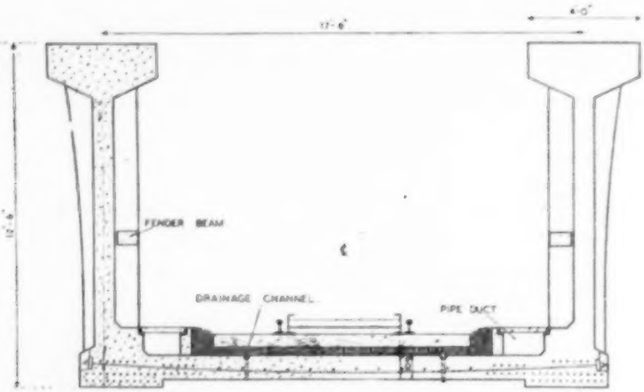


Fig. 25.—Cross Section of Bridge with Prestressed Deck.

square inch, and with a pressure-pot it may not be safe to develop a greater pressure than 50 lb. per square inch. *Fig.* 26 shows an American worm-driven grouting pump. It is usual to blow water through the ducts and then blow the duct clear with air before commencing the grouting.

In the paper acknowledgment is made to the assistance given by Mr. G. Kee, B.Sc.(Eng.), A.M.I.C.E., and Mr. S. Attygalle, B.Sc.(Eng.).

Fig. 26.—High-pressure Screw-driven Grouting Pump in use in the U.S.A.

Design of Tee-beams and Hollow-tile Floors.

By DEREK A. CRESWELL, A.M.I.Struct.E.

THE problem analysed by Mr. H. J. Hopkins, D.F.C., in the October, 1954, number of this journal has been examined, and in the following is a design chart (*Fig.* 2) the use of which eliminates all but simple mathematics.

The unknown or variable factors in the design of a tee beam are: b, the breadth of flange used or required; d_s, the thickness of the flange; d, the effective depth. *Fig.* 1 shows a tee beam with the usual stress-variation diagram. The tensile stress in the steel is

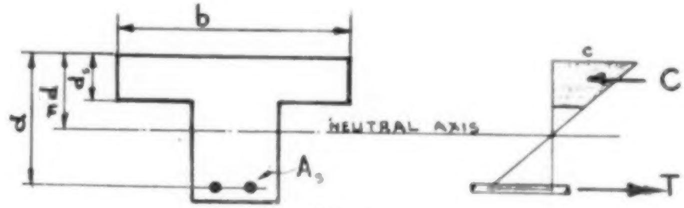


Fig. 1.

$$t = cm\frac{(1 - n)}{n} \qquad (1)$$

where c is the maximum stress in the concrete, m is the modular ratio, and n the proportion of effective depth in compression.

$$T, \text{ the total tensile force} = A_s cm\frac{(1 - n)}{n} \qquad (2)$$

$$C, \text{ the total compressive force} = bd_s\frac{c}{2}\left\{1 + \left(\frac{nd - d_s}{nd}\right)\right\} \qquad (3)$$

As the small amount of concrete in compression in the rib above the neutral axis is generally ignored, the distance from the neutral axis to the centre of gravity of the compressive stress in the flange is

$$\frac{3nd - d_s}{3(2nd - d_s)}.ds + (nd - d_s) \qquad (4)$$

The total moment of resistance, that is the moment of total compressive force about the centre of the steel, is

$$M = bd_s\frac{c}{2}\left\{1 + \frac{(nd - d_s)}{nd}\right\}\left\{\frac{3nd - d_s}{3(2nd - d_s)}.d_s + (d - d_s)\right\} \qquad (5)$$

By writing $\dfrac{d}{d_s} = K$, and as $n = \dfrac{cm}{t + cm}$, equation (5) may be changed to

$$\frac{M}{bd_s^2} = \frac{c}{2}\left\{2 - \frac{t + cm}{Kcm}\right\}\left\{\frac{\dfrac{3cmK}{t + cm} - 1}{\dfrac{6cmK}{t + cm} - 3} + (K - 1)\right\} \qquad (6)$$

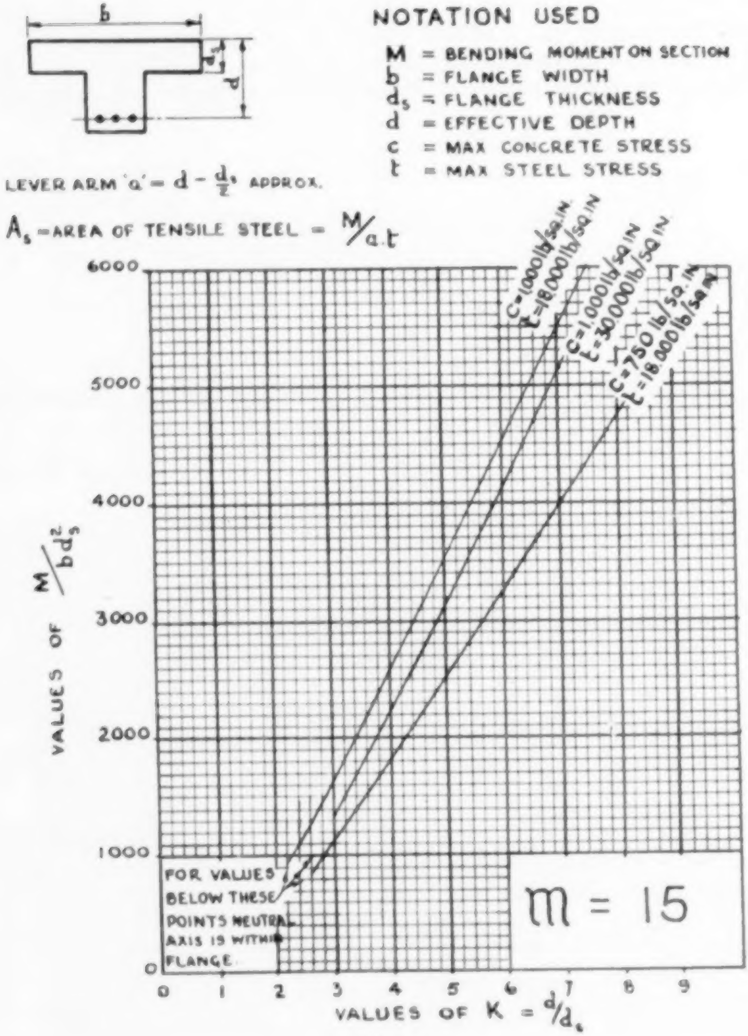

b
d_s
d
NOTATION USED
M = BENDING MOMENT ON SECTION
b = FLANGE WIDTH
d_s = FLANGE THICKNESS
d = EFFECTIVE DEPTH
c = MAX CONCRETE STRESS
t = MAX STEEL STRESS
LEVER ARM 'a' = $d - \frac{d_s}{2}$ APPROX.
A_s – AREA OF TENSILE STEEL = $M/a.t$
C=1,000 lb/sq.in
t=18,000 lb/sq.in
C=1,000 lb/sq.in
t=30,000 lb/sq.in
C=750 lb/sq.in
t=18,000 lb/sq.in
VALUES OF M/bd_s^2
6000
5000
4000
3000
2000
1000
0
FOR VALUES BELOW THESE POINTS NEUTRAL AXIS IS WITHIN FLANGE
m = 15
0 1 2 3 4 5 6 7 8 9
VALUES OF $K = d/d_s$

Fig. 2.

The chart (*Fig.* 2) is based on this equation and relates the unknown factors previously mentioned in such a way that if two are known the other may be found.

Application to Hollow-Tile Floors.

For any given span and load M is known, b is determined by the width of the rib and tile, and d_s depends on the type of floor and tile. The effective depth d is unknown and may be found by the method used in the following example.

Consider a floor with a span of 15 ft. and the weight of the superimposed load and finishes = 185 lb. per square foot; $t = 18{,}000$ lb. per square inch; $c = 750$ lb. per square inch; and $m = 15$. If the width of the rib is 4 in. and the width of the tile 12 in., $b = 16$ in.; d_s is assumed to be $1\frac{1}{2}$ in.

$$M = 185 \times 15^2 \times 1 = 41{,}700 \text{ in.-lb. per foot width} = \frac{16}{12} \times 41{,}700 \text{ in.-lb. per rib.}$$

$$\frac{M}{bd_s^2} = 1545.$$

From *Fig.* 2, $K = \frac{d}{d_s} = 3{\cdot}6$; therefore $d = 3{\cdot}6 \times 1{\cdot}5 = 5{\cdot}5$ in. A slab $6\frac{1}{2}$ in. thick should be used.

Application to Main Tee Beams.

As the thickness of the flange depends upon the thickness of the slab it is usually known. The bending moment can be determined if the weight of the beam is assumed. The variables or unknowns are the width b of the flange and the effective depth d. If d is as small as possible, then the full allowable width of flange must be used, and *Fig.* 2 can be used to find d as in the previous example. If d is unrestricted, and a reasonable depth is assumed, based on a depth-span ratio, then *Fig.* 2 may be used to determine the width of the flange of the beam.

EXAMPLE.—Consider the floor in the previous example to be supported on beams spanning 30 ft. Since the depth is not controlled the beam will be assumed to have an effective depth of 30 in. and a width of rib of 12 in. The bending moment will be 4,190,000 in.-lb. As the thickness of the flange d_s is 6·5 in., $K = \frac{d}{d_s} = \frac{30}{6{\cdot}5} = 4{\cdot}61$. From *Fig.* 2, with $K = 4{\cdot}61$ and $c = 750$, $\frac{M}{bd_s^2} = 2250$ and $b = \frac{4{,}190{,}000}{6{\cdot}5^2 \times 2250} = 44$ in.

The hollow-tile floor must therefore be solid for 22 in. on each side of the centre-line of the beam.

It is doubtful if an accurate analysis of the lever arm is warranted except in very large beams. The error in assuming that the lever arm $a = d - \frac{d_s}{2}$ results in slightly more steel being used. It is rarely possible to use the theoretical area of reinforcement required, and, if the nearest area below that calculated is used, any error is probably cancelled.

The Design of Silos.

ALLOWANCES FOR INCREASES IN PRESSURE DURING EMPTYING.

A METHOD of determining the horizontal pressure on the walls of silos was presented by M. Marcel Reimbert to a meeting, held in Paris in the year 1943, of the Institut Technique du Bâtiment et des Travaux Publics. During 1954 it was possible to determine experimentally the pressures on the walls of full-size silos. It is believed that M. Reimbert's method is not well known in this country and an outline of it is therefore given in the following.

Calculation of Pressures.

Notation: δ, weight per unit volume of the contained material; ϕ, angle of internal friction of the material; ϕ^1, angle of friction of the material on the sides of the silo; S, area, on plan, of the silo; C, perimeter of the walls; r, hydraulic radius $\left(\frac{S}{C}\right)$; z, depth of material at the section being considered; p_z, lateral pressure at a depth z; q_z, average vertical pressure at a depth z; R, radius of a circular silo or the radius of the inscribed circle of a silo in the shape of a regular polygon; A, a constant depending on the shape of the silo and the properties of the contained material. If $h = R \tan \phi$, then

$$A = \frac{r}{\tan \phi^1 \tan^2\left(\frac{\pi}{4} - \frac{\phi}{2}\right)} - \frac{h}{3}.$$

The pressure at depth z is

$$p_z = \frac{\delta r}{\tan \phi^1}\left[1 - \left(\frac{z}{A} + 1\right)^{-2}\right],$$

and the maximum pressure is

$$p_{max} = \frac{\delta r}{\tan \phi^1}.$$

The vertical pressure on the base is

$$q_z = \delta\left[z\left(\frac{z}{A} + 1\right)^{-1} + \frac{h}{3}\right].$$

For rectangular silos with sides a and b, when a is less than b the pressure on the shorter sides may be assumed to be that on a square silo with sides of a length a, and the average pressure on the longer walls may be assumed to be that on a square silo with walls equal in length to $\frac{2ab - a}{b}$. M. Reimbert states also that for silos with comparatively rough walls, for example reinforced concrete walls, the lateral pressures should be computed for the least values of δ, ϕ, and ϕ^1, and the vertical pressures for the least values of δ and ϕ but the greatest values of ϕ^1. For silos with smooth walls (for example steel) the lateral and horizontal pressures should be calculated for the greatest values of δ and ϕ and the least value of ϕ^1.

Tests.

It is well known that considerable increases in the lateral pressure occur during the emptying of a silo and it has been suggested at various times that the static pressures calculated by methods such as that given in the foregoing, or by those due to Janssen or Airy, should be increased by varying amounts. To determine the actual pressures which occurred in silos both during emptying and while being filled, experiments have been carried out by M. Reimbert on full-size silos. The results of the tests were reported in the November, 1954, number of the French journal "Travaux," from which the following is abstracted.

Tests primarily to determine the dynamic increase in pressure on emptying a silo were carried out on steel silos 13 ft. 6 in. square by 33 ft. high and with a capacity of 147 tons. The pressures before and during emptying were determined by measuring the strains in the walls at various depths with electric strain-gauges. The ratios of the pressures while the grain was static compared with those as emptying took place are shown in *Fig.* 1 for two of the tests. It is believed that the differences between the ratios may be explained by different speeds of filling or emptying, and it may therefore be concluded that it is not possible to calculate the increase in pressure with great precision.

A suggested method of reducing this increase in pressure is the use of a tube with holes in its walls, as shown in *Fig.* 3, with the lower end of the tube over the

STRONGER AND BETTER CONCRETE with the NEW Winget 'VIBROCON' VIBRATING SPADE

13,000 Full Impulses per minute from the Model 55

9,000 Full Impulses per minute from the larger Model 70

On jobs demanding vibration methods the higher frequencies of Winget ' Vibrocon ' Vibrating Spades give swifter compaction to maximum density. The workability of harsh mixes is increased and thorough consolidation can be achieved in 30 seconds. Use Model 70 ($2\frac{3}{4}''$ dia.) for mass concrete and Model 55 ($2\frac{1}{4}''$ dia.) for closer reinforcement or smaller sections. There are no gears or belts and operation is extremely simple. Choice of three drives—Petrol, Electric or Pneumatic.

Greater strength. Greater density and homogeneity. Less shrinkage. Greater resistance to frost. Better bond between concrete and reinforcement. Better bond at construction joints.

Registered Trade Mark

Winget

CONTRACTORS' PLANT SPECIALISTS

WINGET LTD ROCHESTER KENT ENGLAND

Tel.: Strood 7276 (5 lines) Telegrams: Wingetism Rochester

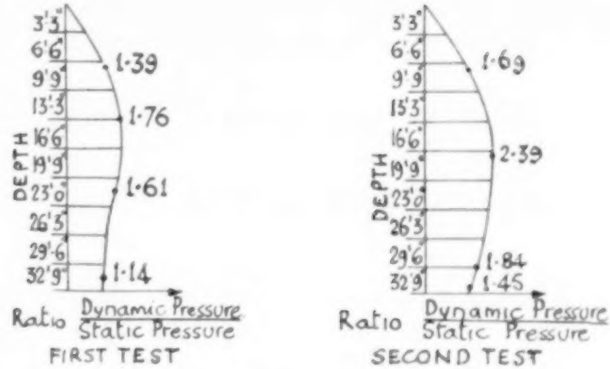


Fig. 1.—Increases of Pressure during Emptying of Silo.

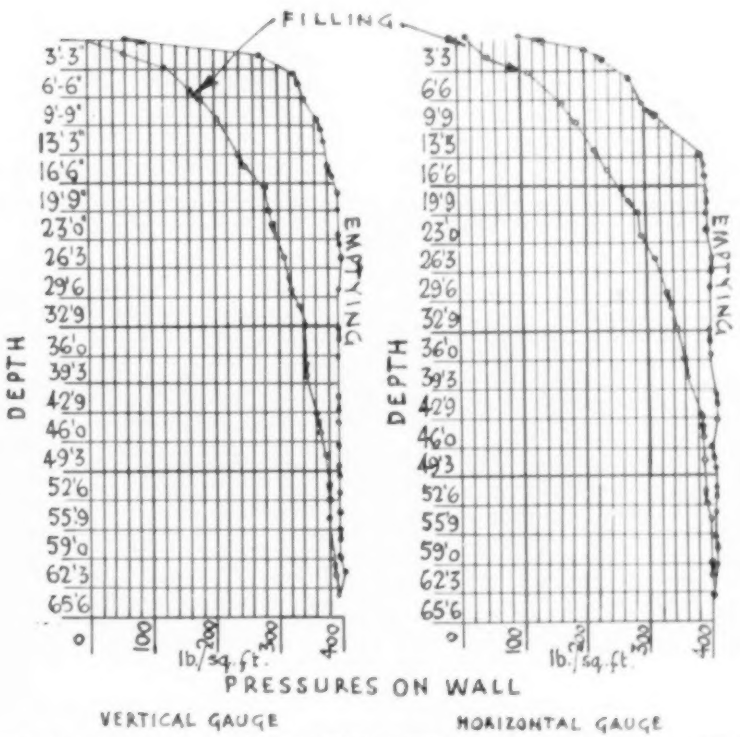


Fig. 2.—Pressures measured during Emptying and Filling a Silo fitted with a Tube.

Fig. 3.—Pierced Tube to Prevent Increase of Pressure during Emptying.

outlet. When the silo is full the pressure exerted on the walls, which is a function of the mean hydraulic radius, is very much greater than that of the grain inside the tube of which the mean hydraulic radius is relatively small; therefore when the outlet is opened the grain within the tube moves while the grain in the silo remains immobile. As the grain in the tube falls some of the grain outside the tube will penetrate the holes and fall inside the tube—but the mass of grain will not move. In this way the grain moves in a smooth continuous manner and dynamic forces do not occur.

Tests have also been carried out on a sheet-steel silo in which was fixed a tube such as that described. This silo is 71 ft. 6 in. high and octagonal on plan with walls 6 ft. 6 in. long. The strain in the walls due to pressure of the grain was measured by electric strain-gauges at depths from the top of 13 ft., 32 ft. 6 in., and 65 ft. At the depth of 65 ft. two gauges were placed, one horizontally and one vertically, so that the strains recorded by one gauge could be compared with those recorded by the other. In *Fig.* 2 are shown the pressures at a depth of 65 ft. due to filling and emptying the silo, and in *Fig.* 4 are shown the measured pressures at all depths when the silo is full, compared with those computed by M. Reimbert's method. In addition, *Fig.* 4 also shows the curve of pressures calculated by Janssen's method. [This

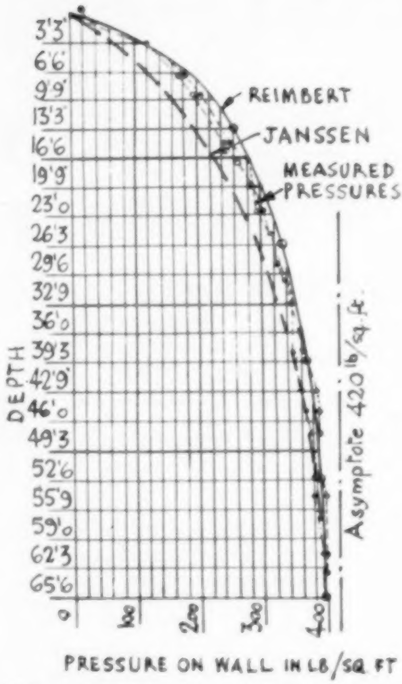


Fig. 4.—Comparison of Computed and Measured Pressures.

curve has been added to the original graph as Jannsen's method is frequently used in this country, and a direct comparison of the methods is thus shown.]

Fig. 2 shows that there is no material increase in pressure during emptying the silo. It may be concluded, therefore, that where a silo is equipped with a tube as described the pressures may safely be assumed to be those computed by M. Reimbert's method, but that where a silo is not so equipped the calculated pressures should be increased to allow for the dynamic increases in pressures due to the emptying of the silo. The amount by which the pressure is increased should be determined by tests such as those described.—J. E. G.

Reconstruction of Parkeston Quay, Harwich.

By D. PEARSON.

THE eastern section of Parkeston quay, Harwich, owned by the British Transport Commission, was constructed between 1881 and 1884. It is 1800 ft. long by 100 ft. wide, is equipped with 30-cwt. and 5-tons' cranes and one 30-tons' crane, and there is rail access to the quayside. This portion provided berths for frequent shipping services, a repair berth and dolphin at the east end, and a cargo berth adjacent to the 30-tons' crane at the west end. In 1949 the old timber and iron work in the deck and much of the piling could no longer be economically maintained. A contract for the renewal of the superstructure was let to Messrs. W. & C. French, Ltd., and work commenced early in 1952 and was completed late in 1954 at a cost of £300,000. The work was designed and supervised under the direction of Mr. J. I. Campbell, M.I.C.E., formerly Chief Civil Engineer, Eastern Region, British Railways.

The original quay had a timber deck carried on timber bearers and piles at the rear and on steel and wrought-iron joists on cast-iron screw-piles at the front. The waterfront, which carried the crane track, was supported on two blue-brick walls with a plain concrete footing bearing on two rows of plain concrete cylinders 9 ft. diameter at 11-ft. centres. The front sill and timber walings were carried on a single row of cast-iron screw-piles filled with concrete. Apart from the front row of screw-piles and a small number of piles at the east end that had been damaged, the substructure was in fair condition and required repair only.

The new work (*Fig.* 1) was confined to the superstructure and fendering only and, in view of the scarcity of steel and timber, serviceable recovered materials were used in the new work as much as possible. The new deck has to carry Diesel shunting locomotives and was designed for loco. rating R.A.4. Timber exposed to seawater had been attacked by teredo and gribble worm and many timber piles at the rear were repaired by removing the

Fig. 1.—The New Front.

tops down to sound timber about 1 ft. below mud level and retopping with creosoted sound timber. Forty piles were in a very bad state and were replaced by steel box-piles, the exposed tops being encased in precast concrete pipes as protection against corrosion (*Fig.* 2). Owing to the exposed position, the deck above these piles was constructed across its entire width in reinforced concrete.

Concrete tops (*Fig.* 3) were cast on to the cylinders, where required, above low water, and a 1 : 1 mixture of sand and sulphate-resisting cement was pumped in under pressure to fill cracks and cavities. Under-water damage was made good by building up with rich concrete contained in sandbags and placed by a diver. The plain concrete wall above the cylinders was grouted where cracked, and where extensive longitudinal cracks had occurred it was strapped with old rails encased in concrete. The two blue-brick walls (shown hatched in *Fig.* 3) were in good condition.

Reinforced concrete buttresses (*Fig.* 4) at 11-ft. centres replaced the front row of screw-piles which were removed by explosive (12 oz. to 1 lb. per pile) cutting under water. These buttresses are secured to the existing front wall with shear bars (*Fig.* 5) and are braced laterally with reinforced concrete walings precast on the site. Every alternate buttress carries a fender. Difficulty was encountered in providing a temporary fixing for the precast walings and shuttering of the buttresses owing to the strong current in the river Stour and the 12-ft. tidal range, but the scaffolding hung from and braced against the front wall (*Fig.* 6) proved satisfactory. All the cement used for parts exposed to sea-water was sulphate-resisting and the remainder ordinary Portland cement.

Fig. 2.—Concrete Pipes Encasing Steel Piles.

The new sill beam of precast concrete is carried on the new buttresses and anchored with tie-bars into the concrete deck. Behind the sill for a width of 21 ft. the deck is formed with precast slabs (*Fig.* 7). The reinforcement of

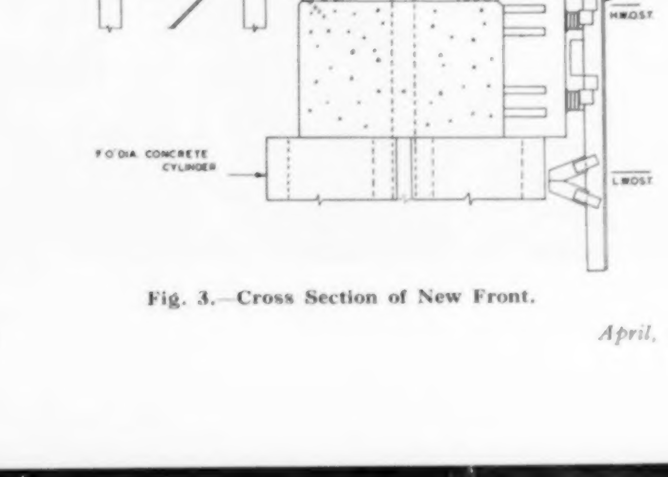


Fig. 3.—Cross Section of New Front.

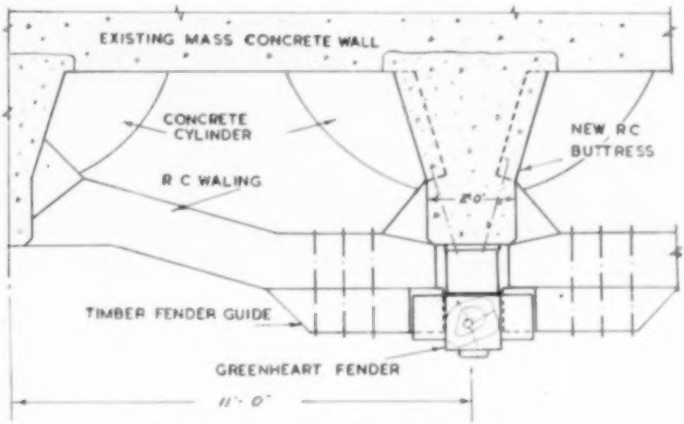


Fig. 4.—Sectional Plan at a Buttress.

these slabs, which support travelling cranes weighing 80 tons each, is of recovered joists or old rails. The remaining 40 ft. of the concrete section consists of a filler-joist deck 5 in. thick as in *Fig.* 8, which shows the reinforcement and method of supporting the channel-shaped timber centres. The 9-in. by 7-in. joists at 2-ft. 9-in. centres were recovered from the existing deck and only 35 tons of new joists were used throughout the work. After the centres were removed the underside of the joists were covered with gunite 1 in. thick.

At the east end a new dolphin was constructed consisting of nine steel box-piles capped with a concrete slab. The fenders are fastened directly to the dolphin, the piles acting as shock absorbers.

The face of the quay is protected by sprung fenders at 22-ft. intervals. These fenders are of three types [*Fig.* 9 (a), (b) and (c)]. Greenheart timber has been used to resist the borings of marine worms and the face is protected against wear by a wrought-iron rubbing strip. All three types of fender are 30 ft. long and project 5 ft. above quay level. Types (a) and

Fig. 5.—Reinforcement for Buttress.

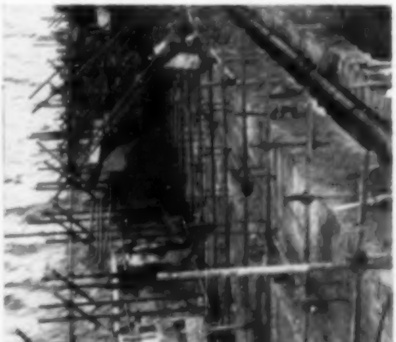


Fig. 6.—Suspended Scaffolding.

Fig. 7.—Precast Deck Slabs.

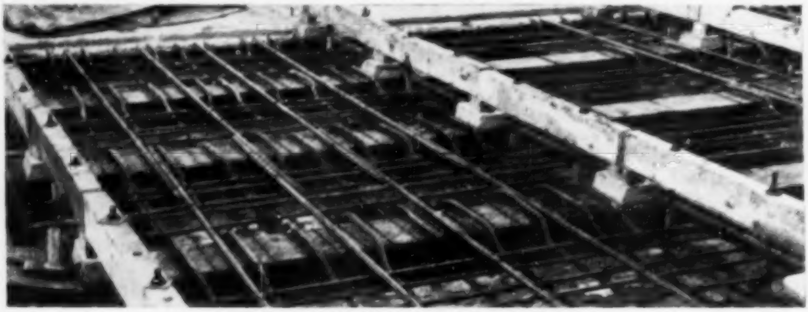
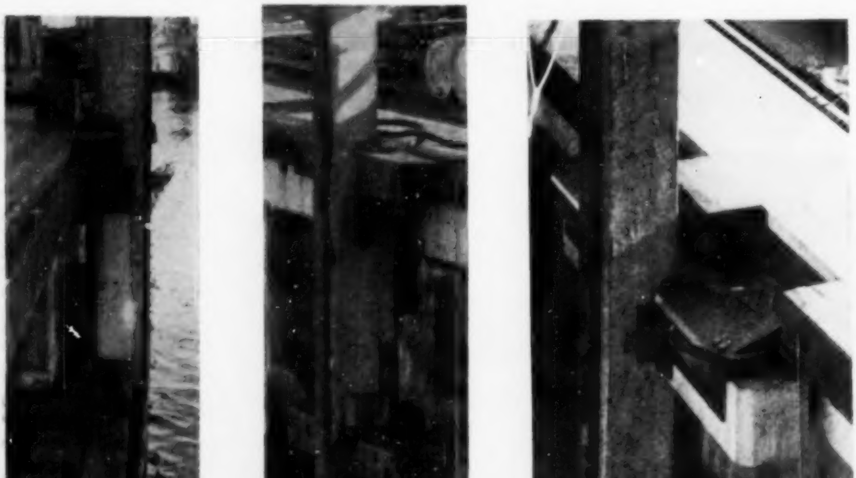
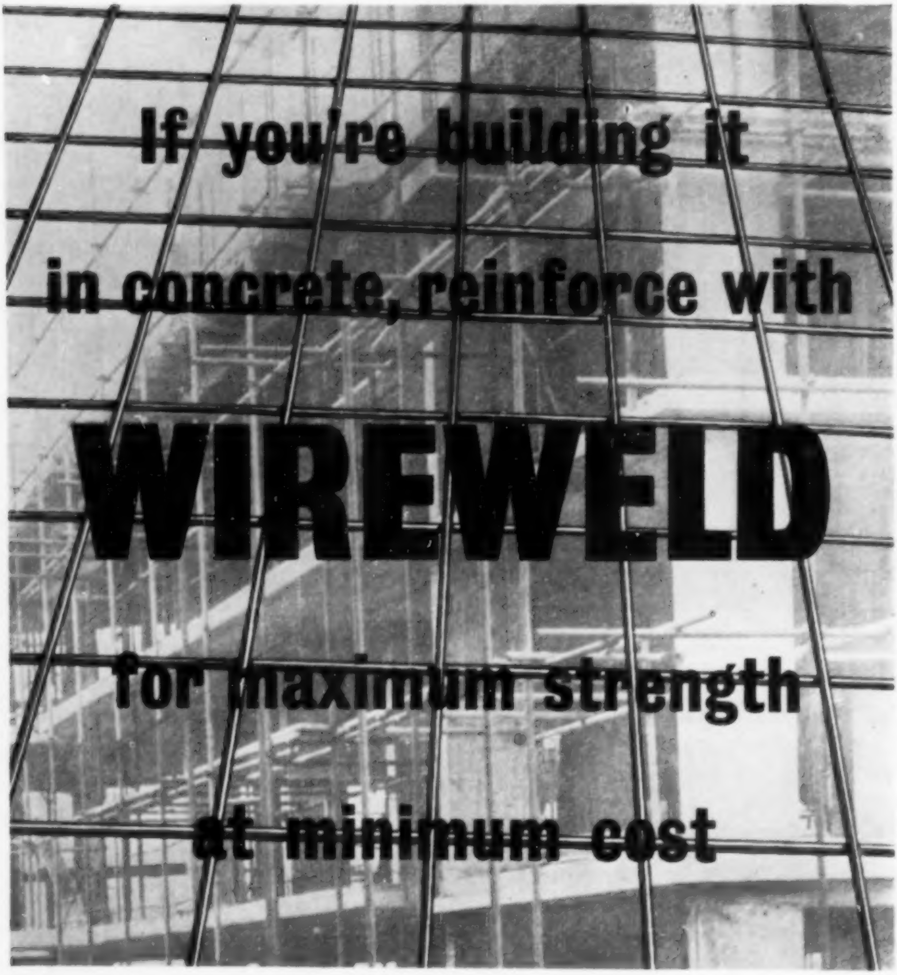


Fig. 8.—In-situ Deck.



(a) (b) (c)

Fig. 9.—Details of Fenders.


If you're building it
in concrete, reinforce with
WIREWELD
for maximum strength
at minimum cost

(b) are supported by timber blocks resting on fender guides attached to the walings, while type (c) is supported by timber cross-heads attached to the springs which in turn are fixed to the sill beam and walings. Type (a) is fitted with three spring units acting in direct compression. Each unit consists of four discs of 14 in. diameter with galvanised steel-plate separators threaded over a $1\frac{3}{4}$-in. diameter bolt which, with a front and back plate of steel, anchors the fender to the quay. Type (b) has three springs each consisting of a single piece of rubber 10 in. by 8 in. by 2 ft. 6 in. with a longitudinal 3-in. hole through which passes a steel rod clipped into brackets on the fender. These springs also act in direct compression. No front or back plate is used and the fender is anchored by two angles, one at sill level and one between the lower walings. Type (c) has four springs, each a solid cylinder of rubber 21 in. diameter by 4 in. thick bonded to steel plates which are bolted to sill brackets and a cross-head at the top and to waling brackets and a lower cross-head at the bottom. The two cross-heads, bolted to the fender through angle brackets, prevent torsional forces, as any tendency for the system to rotate is resisted by direct shear on two or more springs. These fenders are entirely restrained by the resistance to shearing of the bonded rubber. Movement at right angles to the quay is restricted to 4 in. when the cross-head acts as a stop. The capacities of the fenders are: Type (a), 168 tons-in. (3 springs); Type (b), 180 tons-in. (3 springs); type (c), 200 tons-in. (4 springs).

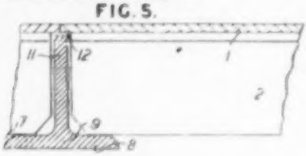
The work was done in sections and throughout the contract normal services were operated.

The writer, who was resident engineer on the site, thanks Mr. J. I. Campbell for permission to publish this article.

PATENT.

Shutters for Curved Surfaces.

A DISMOUNTABLE mould for casting concrete curved surfaces comprises panels each consisting of a flexible rectangular metal sheet (1, *Fig.* 1), reinforced by parallel **V**-section stiffeners (2), portions (12) of the sheet (1) extending beyond the ends of the stiffeners so that the edge portions of adjacent panels abut and overlie the stems (11, *Fig.* 5) of curved parallel **T**-sections supporting ribs (7), whilst the ends of the stiffeners rest on the



cross-bars (9) of the ribs. The ribs are wired to supporting scaffolding, holes (8, *Fig.* 5) in the cross-bars being provided for this purpose, the ends of the stiffeners also being provided with holes for wiring the panels together and to the ribs. The stiffeners extending along the two opposite edges of each panel are distorted (*Fig.* 1) to form abutments so that adjacent panels do not override each other.—No. 688,281. Sir Robert McAlpine & Sons, Ltd., and A. Griffin. March 21, 1951.

[Publication of patent specifications by the Patent Office is in arrears due to the war.]

MISCELLANEOUS ADVERTISEMENTS.

Situations Wanted, 3d. a word : minimum, 7s. 6d. Situations Vacant, 4d. a word : minimum, 10s. Other miscellaneous advertisements, 4d. a word : 10s. minimum. Displayed advertisements, 30s. per column inch. Box number 1s. extra. The engagement of persons answering these advertisements is subject to the Notification of Vacancies Order, 1952.

Advertisements must reach this office by the 23rd of the month preceding publication.

SITUATIONS VACANT.

SITUATIONS VACANT. Draughtsmen-detailers (all grades) required. Good experience in reinforced concrete essential. Five-days' week. Modern office conditions. Also technical assistant for dealing with projects, correspondence, etc. Full details and starting salary to JOHN LIVERSEDGE & ASSOCIATES, Consulting Engineers, 42 Portland Place, London, W.1.

SITUATION VACANT. Technical assistant to director. Age 21–28, graduate or qualified with some drawing office and design experience. Good prospects for young man with initiative and experience in technical estimating, etc., for all types of reinforced concrete structures. London, W.1, district. Full details to BOX 4124, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Required by THE COPPEE CO. (G.B.), LTD., 140 Piccadilly, London, W.1, for colliery structures, bunkers, reservoirs, etc. Reinforced concrete designers, preferably over 28. Some knowledge of steelwork favourably considered but not essential. Reinforced concrete detailers preferably with at least three years' experience. Project engineers capable of quick overall designs and quantities. Pension scheme. Apply stating age, qualifications, experience, and salary required.

SITUATIONS VACANT. Reinforced concrete senior and junior designer-detailers required in Westminster consultant's office specialising in heavy industrial works. Five-days' week, and excellent opportunities. Write GLOVER & PARTNERS, Terminal House, London, S.W.1. Telephone Sloane 6442.

STRUCTURAL ENGINEERING ASSISTANTS

required by

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

at Risley, near Warrington, and Dounreay, Caithness, Scotland.

Applicants must be competent detailers of steelwork and/or reinforced concrete, and should hold an Ordinary National Certificate in engineering. Salary range £455 (at age 21) to £715. Successful candidates will be required to join the Authority's contributory pension scheme. Assisted Travel scheme in operation at Risley, and training concessions, with opportunities for site experience if desired. Unusual work, with long-term possibilities and good prospects.

Applications to THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Industrial Group Headquarters, Risley, Warrington, quoting 883.

(*Continued on page lxv.*)

MISCELLANEOUS ADVERTISEMENTS.

(Continued from page 178.)

SITUATIONS VACANT. Senior engineers required by large civil engineering and building contractors at head office and on sites. Must have wide practical knowledge of civil engineering construction detail based on contracting experience, and take a keen interest in construction problems. Duties will require detailed knowledge of planning, plant, design, pricing, and execution of all kinds of construction work. Applicants must be versatile and have ability to produce rapid and accurate results. Assistant engineers who are desirous of gaining experience in the above field, and prepared to work hard to consolidate their future, are also required. The right men will have progressive and superannuated positions. Write giving full details, which will be treated confidentially, to M.D. Engineer, Taylor Woodrow Construction, Ltd., Ruislip Road, Southall, Middlesex.

SITUATIONS VACANT. Reinforced concrete detailers required, with sound knowledge and experience, for permanent positions. Five-days' week. Pension scheme. Apply by letter to E. J. Cook & Co. (Engineers), Ltd., Lynton House, 54 South Side, Clapham Common, London, S.W.4.

SITUATIONS VACANT. AIR MINISTRY Works Designs Branch requires, in London, structural engineering designer/draughtsmen for reinforced concrete or structural steelwork with sound technical training and several years' varied experience in design/detailing of (*a*) Reinforced concrete construction for all types of buildings, or (*b*) steel-framed sheds, warehouses and similar buildings. Salaries up to £810 per annum, starting pay dependent upon age, qualifications and experience. Extra-duty allowance or overtime payable. Posts non-pensionable with long-term possibilities. Natural-born British subjects only. Write, stating age, qualifications, employment details, including type of work done, to Ministry of Labour, 236 Walworth Road, London, S.E.17, quoting Order 82/BA.

SITUATION VACANT. Concrete formwork designer-draughtsman required by civil engineering contractors in Westminster. Apply in writing only, stating age, experience, and salary required, to Peter Lind & Co., Ltd., Romney House, Tufton Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete designer-draughtsmen and detailers required by Ashmore, Benson, Pease & Co., Stockton-on-Tees. Applicants should be fully experienced in either designing or detailing reinforced concrete structures, foundations, and other civil work. Pension scheme, technical library, sports facilities available, also company's flat. Apply, stating age, experience, etc., quoting reference D, to Staff Personnel Officer.

SITUATIONS VACANT. Experienced reinforced concrete designers and detailers required by consulting engineers in their Sunbury office. Five-days' week. Permanent position, good salary and prospects. Apply, stating age and experience, to J. H. Coombs & Partners, Thames Corner, Sunbury-on-Thames.

SITUATION VACANT. Detailer-draughtsman required for varied reinforced concrete work. Permanent, progressive, and superannuated post. 36½ hours' week. Alternate Saturdays. Telephone for appointment (Mr. Disney), the Rom River Co., Ltd., Euston 7814.

SITUATION VACANT. Structural engineer required by civil engineering contractors in London, S.W.3, for the design of reinforced concrete structures. Applicants need not have specialised in concrete design but should be familiar with normal methods of structural analysis. Permanent position. Salary in accordance with qualifications and experience. Please reply in own handwriting to Box 4130, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Research engineer required by the Research and Development Division of the Cement and Concrete Association, near Slough, to work on concrete materials and methods of construction. Preference given to candidates about 27 years of age with Honours Degree in Engineering and one or two years' practical experience. Salary according to qualifications and experience. Opportunities for obtaining higher degrees and specialised knowledge. Write, with full particulars, to the Secretary, Cement and Concrete Association, 52 Grosvenor Gardens, London, S.W.1.

INTERMEDIATE DRAUGHTSMEN

Required for expanding office of Consulting Engineers engaged on varied schemes in Reinforced Concrete and Structural Steel construction. Offering permanent posts with :

(i) Salary commensurate with experience.
(ii) Favourable working hours, with optional overtime.
(iii) Opportunities for part-time study.
(iv) Prospects of rapid advancement.

Applications immediately to Box 4135, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Experienced designer-draughtsman required for London head office of old-established reinforced concrete engineers specialising in hollow-tile type floor construction. Applicants must be capable of taking charge of and supervising medium-size drawing office, and possess knowledge of current by-laws and codes of practice. Permanent, progressive, and pensionable post. Write fully qualifications, experience, and salary required, to Box 4133, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. The British Reinforced Concrete Engineering Co., Ltd., have vacancies for reinforced concrete designers and detailers, with experience, in their Stafford, London, Liverpool, Bristol, Newcastle-on-Tyne, and Glasgow offices. Staff pension scheme and five-days' week. Apply in writing to Chief Engineer, Stafford.

SITUATION VACANT. Reinforced concrete detailer required for consulting engineer's office. Good experience in reinforced concrete essential. Five-days' week. Apply in writing, giving details of experience and salary required, to F. J. Samuely, 8 Hamilton Place, London, W.1.

SITUATION VACANT. Surrey County Council requires structural engineering draughtsman, Grade II. £560 × £20 — £640 per annum, plus London allowance. Must be neat concrete detailer. Knowledge of design an advantage. Full details and three copies of testimonials to County Architect, County Hall, Kingston, by 20 April, 1955.

SITUATIONS VACANT. Reinforced concrete detailer-draughtsmen required by consulting engineers, West London. Excellent salary and prospects. Write A. Bickerdyke & Co., 4-6 Hammersmith Grove, London, W.6.

SITUATIONS VACANT. Consulting civil and structural engineers invite applications for permanent appointments as senior engineers, designers and detailers. Applicants must be experienced. Wide variety of interesting work at home and abroad on normal reinforced concrete, steelwork, prestressed concrete, etc. Scope for initiative and progressive advancement. Apply, giving details of experience, to R. Travers Morgan & Partners, 11 Victoria Street, London, S.W.1.

SITUATION VACANT. Senior reinforced concrete designer required by the Indented Bar & Concrete Engineering Co., Ltd. Only men experienced in the design of all classes of reinforced concrete structures need apply to 171 Victoria Street, London, S.W.1.

SITUATION VACANT. Draughtsman (civil engineering) required by consulting engineers in Westminster. H.N.C. studies as basis of technical education. Previous experience of reinforced concrete advantageous. Salary will be according to experience. Box 4136, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. The Trussed Concrete Steel Co., Ltd., have vacancies in their London, Birmingham, Glasgow, and Manchester offices for reinforced concrete designers and detailers. Five-days' week. Pension scheme. Apply, giving full particulars of age, education, and previous experience, to the Secretary, Truscon House, 35-41 Lower Marsh, London, S.E.1.

SITUATIONS VACANT. Reinforced concrete designers and draughtsmen with at least two years' office experience required. Interesting work and good prospects. Five-days' week. Apply in writing, stating full particulars, to Christiani & Nielsen, Ltd., Romney House, Tufton Street, London, S.W.1.

(Continued on page lxvi.)

MISCELLANEOUS ADVERTISEMENTS

(*Continued from page* lxv.)

SITUATION VACANT. Civil engineer required by progressive expanding company with overseas associates. Applicants must be qualified concrete specialists capable of controlling laboratory and field work, with experience and full understanding of modern concrete practice and placing technique. Successful applicant will be based in London. Reply initially in confidence, stating age, qualifications, experience, and salary required, to Box 4137, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Qualified civil or structural engineer required by London contractor for work on a large site in the City of London. Thorough experience in the construction of deep foundations essential as well as the ability to agree details of the methods of construction with the consulting engineers. Salary by arrangement. Apply, giving full details, to GALBRAITH BROS., LTD., Crayford Bridge, Crayford, Kent.

SITUATIONS VACANT. Several civil engineering draughtsmen required for work in London office of large oil company. Experienced in the preparation of designs and calculations for foundations and steel or reinforced concrete structures. Also the preparation of specifications and bills of quantities. Candidates with at least H.N.C. or equivalent and a good basic training in civil engineering. They should also be willing to serve overseas if required. Salary £700–£900, according to qualifications and experience. Pension fund. Write in detail, quoting No. 467, to Box 8490, CHARLES BARKER & SONS, LTD., 31 Budge Row, London, E.C.4.

SITUATIONS VACANT. Reinforced concrete designer and detailer-draughtsmen required by KLEINE CO., LTD., for their London offices. Applicants should preferably be experienced in light frame and/or floor construction. Permanent and progressive posts. Write, giving full details of age, qualifications, experience, and salary expected to 9–13 George Street, Manchester Square, London, W.1, or telephone WELbeck 9131 for an appointment.

SITUATIONS VACANT. Reinforced concrete designers and detailers required by consulting engineers for varied and interesting building frames and industrial structures. Salary £500 to £700 per annum, according to experience. Apply with details to JOHN F. FARQUHARSON & PARTNERS, Chartered Structural Engineers, 34 Queen Anne Street, London, W.1. LANgham 6081.

SITUATIONS VACANT. Experienced reinforced concrete and structural steelwork designers and detailers required urgently. Salary according to qualifications and experience. Pension scheme, five-days' week, and paid overtime. Two weeks' holiday this year if starting before May 1st. Three weeks' holiday after one year's service. Write, stating when free, age, qualifications, and experience. Salary range £850–£1,200 per annum. BRIAN COLQUHOUN & PARTNERS, 18 Upper Grosvenor Street, London, W.1.

SITUATIONS VACANT. Reinforced concrete designers and detailers required by consulting engineers to work in Surrey office. Good working conditions and five-days' week. Salaries £500–£900 per annum, according to experience and ability. Permanent positions with excellent prospects. Apply, giving full details, to Box 4138, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete designers and draughtsmen are required by reinforcement manufacturers for their Bristol office. Permanent, pensionable posts with good prospects to men with sound experience in reinforced concrete or building trade. Box 4139, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Consulting engineers have vacancies for qualified engineering assistants in Kenya with experience in the design of reinforced concrete and steelwork structures, with site supervision. (A knowledge of surveying will be an advantage.) Varied projects with scope for initiative and opportunities for advancement. Candidates should be single, and between the ages of 24 and 32. Salary, leave facilities and other terms of appointment in accordance with experience. Air passages for applicants from abroad will be paid. Applications, which should be made in writing, giving full particulars of age, education, qualifications and experience, with some recent references, should be addressed to PETER M. AMCOTTS & PARTNERS, P.O. Box 6505, Nairobi, Kenya.

SITUATIONS VACANT. Civil engineering draughtsmen (senior and junior) required. Opportunities for extensive experience. Pension and bonus schemes. Write, stating experience and salary, to L. G. MOUCHEL & PARTNERS, LTD., 38 Victoria Street, London, S.W.1.

SITUATIONS VACANT. Two vacancies exist in the London office of large civil engineering contractors for reinforced concrete designer-draughtsmen. The work is of an extremely varied nature and offers good scope for man with initiative to advance himself. Ideal conditions, five-days' week, good salary, bonus, and luncheon vouchers. Pension scheme operates. Apply in writing to Box 4140, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Tarmac, Ltd., require senior estimator for concrete products. Able to read drawings and prepare own quantities. Up-to-date experience essential. This appointment is permanent and well paid. Write, giving full details of experience, and salary required, to CLERICAL MANAGER, TARMAC, LTD., Ettingshall, Wolverhampton.

SITUATION VACANT. Consulting engineers require detailer age 22–25 with 3 to 4 years' experience of reinforced concrete structures. Work varied and interesting, and offers excellent opportunity for right man to gain experience of marine, bridge, and other large contracts. For application form send postcard to SIR BRUCE WHITE, WOLFE BARRY & PARTNERS, 1 Lygon Place, London S.W.1.

SITUATION VACANT. Draughtsmen-detailers, age 22 upwards, having comprehensive experience in reinforced concrete, required for interesting and varied work in London head office. Good prospects and salary for right men. Five-days' week. Pension scheme operates. Apply with details of experience to GEORGE WIMPEY & CO. LTD., Planning Department, 27 Hammersmith Grove, London, W.6.

SITUATION WANTED.

SITUATION WANTED. M.I.Struct.E. accustomed to executive responsibility and experienced in the professional and commercial fields of structural and civil engineering and building, especially reinforced and precast concrete, seeks senior post at home or abroad. Box 4124, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

FOR SALE.

FOR SALE. Steel fencing stakes, chain link, etc. E. STEPHENS & SON, LTD., Bath Street, London, E.C.1.

FOR SALE. Steel tubing, 3000 ft. 3½ in. o/d × 2¾ in. i/d, lengths 14/16 ft., at 2s. per foot. Many other sizes for disposal. List on application. E. STEPHENS & SON, LTD., Bath Street, London, E.C.1. Telephone Clerkenwell 1711.

FOR HIRE.

FOR HIRE. Lattice steel erection masts (light and heavy), 30 ft. to 150 ft. high, for immediate hire. BELLMAN'S, 21 Hobart House, Grosvenor Place, London, S.W.1.

Bar facts

Besides setting new high standards in tensile and bond strength, the TENTOR BAR possesses two other advantages that are of outstanding importance to all structural engineers engaged on reinforced concrete design.

YOUR JOB COSTS LESS AND ALWAYS PROCEEDS TO PROGRAMME WHEN YOU SPECIFY TENTOR BARS

The
TENTOR BAR
Company Limited
43, Upper Grosvenor St., London, W.1
Telephone : GROsvenor 8101

Complete technical information is freely available and will gladly be sent on request.

Tentor is manufactured by
Guest Keen & Nettlefolds (South Wales) Ltd., Cardiff.
McCall & Co. (Sheffield) Ltd., Templeborough, Sheffield.
The United Steel Companies Ltd., Sheffield.

Published by Concrete Publications Ltd., 14 Dartmouth Street, London, S.W.1. Telephone: Whitehall 4581
Printed by Butler & Tanner Ltd., The Selwood Printing Works, Frome and London